

A CASE STUDY IN USING ELECTRONIC PRESENTATION

MEDIA TO TEACH MATHEMATICS

B. WATSON

MIPHI 2006

90 0729111 2



REFERENCE USE ONLY

This copy of the thesis has been supplied on condition that anyone who consults it is understood to recognise that its copyright rests with its author and that no quotation from the thesis and no information derived from it may be published without the author's prior consent.

**A case study in using electronic presentation
media to teach mathematics**

by

Brian Watson

**A thesis submitted to the University of Plymouth
in partial fulfilment for the degree of**

Master of Philosophy

**Centre for Teaching Mathematics
Department of Mathematics and Statistics
Faculty of Technology**

September 2006

University of Plymouth Library	
Item No.	9007291112
Shelfmark	374.26 WAT
THESIS	

A case study in using electronic presentation media to teach mathematics

Abstract

Over the past decade the United Kingdom (UK) Government has invested substantially in Information and Communications Technology (ICT) in all sectors of education. Investment has been in infrastructure, staff development and educational software.

At the same time there has been concern about the achievements in mathematics of school leavers and about the decline in numbers of students choosing to study mathematics in Higher Education. Through its Widening Participation initiative, the UK Government intends to increase the number of students entering Higher Education.

An account is given of a project to make appropriate use of computer-based projection materials in the delivery of a two-week mathematics summer school for students about to enter a foundation year which would prepare them for entry to degree courses in mathematics and technology.

Biggs (2003) uses the term constructive alignment to mean "a design for teaching calculated to encourage deep engagement" (Biggs 2003, p32).

This study asserts that computer-based presentation material can be used to implement differentiated pedagogy, which can assist in making mathematics accessible to a group of adults with a wide range of prior attainment in mathematics, thereby assisting in the achievement of constructive alignment.

Contents

Chapter 1 Introduction	1
1.1 Apparent problems with mathematics	1
1.2 Developments with technology.....	4
1.2.1 Multiplication tables.....	4
1.2.2 Solving equations.....	9
1.2.3 Trigonometry.....	11
1.3 Summary	13
Chapter 2: A review of relevant literature	14
2.1 Introduction	14
2.2 Documented problems with mathematics education.....	14
2.2.1 National symptoms.....	14
2.2.2 Summary	20
2.3 Mathematics education	21
2.3.1 The nature of mathematical knowledge.....	21
2.3.2 The purpose of mathematics education	22
2.4 Widening participation	30
2.4.1 Teaching and learning.....	34
2.4.2 Summary	42

2.5 Use of Information and Communication Technology (ICT) in education	44
2.5.1 The case for using technology	44
2.5.2 Pedagogy	48
2.5.3 Summary	50
2.6 Chapter Summary	51
2.6.1 Documented problems with mathematics education.....	51
2.6.2 Mathematics education	52
2.6.3 Widening participation	52
2.6.4 Use of Information and Communications Technology (ICT) in education	52
Chapter 3: Methodology	53
3.1 Introduction	53
3.2 The course which is the subject of the study.....	55
3.2.1 Ethos	56
3.2.2 Course content, teaching methods and assessment	57
3.3 The computer-based presentation materials	59
3.3.1 A basic presentation	59
3.3.2 Illustrated presentations	61

3.3.3 An interactive presentation.....	64
3.4 Data collection.....	69
3.4.1 Rationale.....	69
3.4.2 Methods.....	70
3.5 Chapter Summary.....	73
Chapter 4: Data.....	75
4.1 Introduction.....	75
4.2 Biographical data.....	76
4.3 Data from initial survey.....	77
4.4 Data from feedback questionnaire.....	80
4.5 Scores for tests.....	105
4.6 Initial appraisal of data.....	106
4.7 Comparison of expectation and achievement.....	108
4.8 Conclusion to chapter.....	114
Chapter 5: Analysis of the data.....	115
5.1 Introduction.....	115
5.2 Analysis of students.....	116
5.2.1 Student 1.....	116
5.2.2 Student 2.....	119

5.2.3 Student 3	122
5.2.4 Student 4	124
5.2.5 Student 5	127
5.2.6 Student 6	128
5.2.7 Student 7	131
5.2.8 Student 8	133
5.2.9 Student 9	135
5.2.10 Student 10	138
5.2.11 Student 11	140
5.2.12 Student 12	141
5.2.13 Student 13	142
5.2.14 Student 14	143
5.2.15 Student 15	145
5.2.16 Summary of analysis of students	147
5.2.17 Conclusions from the analysis of students.....	152
5.3 Analysis of topics	153
5.3.1 Order of precedence of arithmetic operations.....	153
5.3.2 Most criticised topic: Fractions	155

5.3.3 Topic most effectively presented: Rearranging formulae....	159
5.4 Summary	161
Chapter 6: A discussion of results	163
6.1 Introduction	163
6.2 Pedagogic aspects	164
6.2.1 Presentation	164
6.2.2 Step-by-step construction of processes	165
6.2.3 Differentiated pedagogy	166
6.2.4 Design of computer based learning materials	170
6.3 Key findings	172
6.4 Summary	173
Chapter 7: Concluding observations	176
7.1 The initial problem	176
7.2 A wider perspective	176
7.3 Implications for teachers	178
7.4 The use of electronic presentation materials	178
7.5 Questions for further research	179
References	180
Appendices	185
Appendix A: Application for Ethical Approval.....	186

Appendix B: Invitation to participate	191
Appendix C: Interview Briefing	193
Appendix D: Initial survey.....	194
Appendix E: Course feedback questionnaire	198
Appendix F: Interview prompts.....	210
Appendix G: Transcript of interviews	221
Appendix H: List of presentation software materials	240
Appendix I: End-of-summer-school test.....	244
Appendix J: Test 1 - Fractions	251
Appendix K: Test 2 - Solve equations	252
Appendix L: Test 3 - Transposition of formulae	253
Appendix M: Test 4 - Indices.....	254
Appendix N: Test 5 - graphs.....	256
Appendix P: Test 6 - Equation of a straight line	259
Appendix Q: Test 7 - Trigonometry	260

List of figures

Figure 1.1: Seven times table, sequential	6
Figure 1.2: Seven times table, non-sequential	8
Figure 1.3: Sequence from computer slide show for solving an equation	10
Figure 1.4: Inverse sine.....	12
Figure 2.1: Growth in number of students in Higher Education	31
Figure 2.2: Student engagement vs teaching methods (Biggs 2003, p8).....	38
Figure 3.1: Interactions in the learning process	54
Figure 3.2: Order of precedence of operations	60
Figure 3.3: Solution of an equation	64
Figure 3.4: Interactive solution of an equation.....	67
Figure 3.5: Interactive solution of an equation – response to input	68
Figure 4.1: Age profile of students on summer school	106
Figure 4.2: Mathematics qualifications of students on summer school.....	106
Figure 5.1: Number of responses relating the topic, Fractions.....	155
Figure 5.2: Example of presentation material for Fractions.....	156
Figure 6.1: Differentiated pedagogy	169

List of Tables

Table 2.1: Cognitive styles (Chinn <i>et al.</i> 1998, p19)	41
Table 3.1: Topics covered on summer school.....	57
Table 3.2: Structure of the Observed Learning Outcomes (SOLO) (adapted from Biggs 2003, p48)	69
Table 4.1: Biographical data.....	76
Table 4.2: Student profiles.....	78
Table 4.3: Responses to question 11	79
Table 4.4: Topics of particular difficulty	81
Table 4.5: What would have made it easier?	82
Table 4.6: Topic identified in question 2.....	83
Table 4.7: Suggested improvements	83
Table 4.8: Topics found to be easy.....	85
Table 4.9: Comments relating to question 3.....	85
Table 4.10: Topics where presentation was considered particularly helpful ...	86
Table 4.11: Aspects which made presentations helpful	87
Table 4.12: Topic which respondents think should have been omitted.	88
Table 4.13: Reasons why topic should be omitted	89

Table 4.14: Topics which respondents consider should be included.....	89
Table 4.15: Reasons why topic(s) should have been included	90
Table 4.16: Topics which could have been better presented	91
Table 4.17: Reasons why presentation could have been better	92
Table 4.18: Topics considered to be particularly effective.....	93
Table 4.19: Reasons why topics were considered particularly effective	94
Table 4.20: 'Yes' response to question 9	95
Table 4.21: 'No' response to question 9	95
Table 4.22: 'Don't know/not applicable' response to question 9	95
Table 4.23: Helpfulness of computer-based presentation material	96
Table 4.24: 'Yes' response to question 10	98
Table 4.25: 'No' response to question 10	98
Table 4.26: 'Don't know/not applicable' response to question 10	98
Table 4.27: Helpfulness of computer-based material used by respondent.....	99
Table 4.28: Time spent by teacher speaking/explaining	99
Table 4.29: Comment relating to question 11	100
Table 4.30: Amount of time for students to work by themselves	100
Table 4.31: Comment relating to question 12	100

Table 4.32: Balance between teacher talking and students working	101
Table 4.33: Comment relating to question 13	101
Table 4.34: Amount of individual support.....	101
Table 4.35: Comments relating to question 14	102
Table 4.36: Did the assessment reflect the content of the course?	102
Table 4.37: Did the assessment reflect the level of the course?	103
Table 4.38: Is the type of assessment appropriate?	103
Table 4.39: Aspects of assessment	103
Table 4.40: Benefits from course	104
Table 4.41: Final scores.....	105
Table 4.42: Comparison of expectation and achievement.....	108
Table 5.1: Summary of analysis of students	151
Table 5.2: Students' comments: order of precedence of operations.....	154
Table 5.3: Criticism of topic, Fractions.....	157
Table 5.4: Support for topic, Fractions.....	158
Table 5.5: Presentations which were particularly helpful to understanding .	159
Table 5.6: What made presentations particularly effective.	160

Acknowledgements

I would like to thank the following people and organisations for all the help and encouragement they have given me with this research programme:

Dr Ted Graham and Professor John Berry for their help and supervision;

All fellow students for their peer support and constructive criticism throughout our *regular meetings*;

support staff in the Centre for Teaching Mathematics and in the Department of Mathematics and Statistics, who have contributed to the congenial working environment of the Centre;

and my wife, Amanda, for supporting my studies in many ways both directly and indirectly.

AUTHOR'S DECLARATION

At no time during the registration for the degree of Master of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee.

Word count of main body of thesis: 37,085

Signed Brian Watson

Date 29th September 2006

Chapter 1 Introduction

1.1 Apparent problems with mathematics

For about four years I provided 'drop-in' support in mathematics for Further Education students. I was available to any student on any course, who wanted assistance with mathematics. Support was provided on a one-to-one basis, or with small groups. I found that some students had difficulty because they had not consolidated the rudiments of number. For example one student had problems ostensibly with speed, time and distance calculations. It transpired that he did not understand decimals. He could follow the logic of speed being distance per unit time, but would convert 3.25 hours as 3 hours and 25 minutes and, after some discussion, confided that he did not understand decimals.

Similarly, engineering students seeking help with calculus have been able to perform the process of integration with confidence but have been unable to perform the final calculation because it involved division by a fraction, (e.g.

$\frac{\pi 5^{\frac{3}{2}}}{\frac{3}{2}}$). There are two causes of concern in this example, firstly the problem

was an inability to divide by a fraction, and secondly that in the students' minds this problem was related specifically to calculus.

The National Curriculum Key stage 3 specifies that students should be able to

recall all positive integer complements to 100 [for example, $37 + 63 = 100$];

and

develop a range of strategies for mental calculation.
(DfEE 1999)

During my time as a lecturer in Further Education I conducted informal oral tests with three different groups of students studying Application of Number on Intermediate General National Vocational (GNVQ) courses, and found that they struggled to perform mental arithmetic such as $3 + 8$. Many counted on their fingers.

Another cause for concern was that some students seeking support appeared not to expect to understand. Students on vocational courses, for example engineering or business studies, often see the related mathematics as arbitrary processes. For example, to increase a value by 5 percent, one can either calculate 5% and add it to the original value, or multiply the original value by 1.05. The correspondence between the two methods is obvious to some and obscure to others. Even business studies students who make use of the formulae for compound interest could be unaware of the equivalence of these two methods. For some, application of the formula for compound interest was, and possibly always will be, an arbitrary process. For others, recognition of this correspondence will make it easier to remember or to deduce the formulae.

In transposition of formulae, application of the dubious rule "change the side, change the sign," was responsible for errors and confusion. The rule can be applied successfully to simple equations of the type, $a = b + c - d$. Anything more complex is liable to reveal the limitations of the rule. On numerous occasions I have had to correct students who have misapplied the 'rule' to equations such as, $a = \frac{b + c}{d}$ and from this have deduced that, $a - c = \frac{b}{d}$, or

that, $\frac{a}{-d} = b + c$.

Transposition requires a sound understanding of the rules of order of precedence of operations. Alas, many students do not have this understanding although they might recall mnemonics such as BODMAS and BIDMAS, which are included in some mathematics text books (Evans, Gordon, Senior and Speed 2003, p143; Berry, Bryden, Cowey and Faulkner 2004, p18). One or other of these mnemonics appears to be remembered easily enough, but what it represents and how to apply it remain mysteries to many. **B**rackets, **D**ivision, **M**ultiplication, **A**ddition and **S**ubtraction usually can be dredged from memory, but does the '**O**' stand for 'of' or 'Order'? The '**I**' in BIDMAS stands for **I**ndices. Does it really matter what the letters stand for if the principle cannot then be applied? Even when its meaning is remembered, its application can fail. One student demonstrated to me that if the mnemonic is applied strictly, then addition should be performed before subtraction. Therefore, to evaluate the expression, $10 - 2 + 1$, firstly the 2 and the 1 should be added and the result then subtracted from 10, giving an answer of 7. The left to right relationship between operation and operand is fundamental, but is it specifically taught or is it implied and assumed?

From my experience of supporting students in tertiary education, it appeared that many students were challenged and daunted by mathematics because they lacked consolidation, understanding and/or confidence in applying basic mathematical and numeracy skills. This raised questions of why this should be so, and how could it be addressed.

1.2 Developments with technology

Initially I would use pencil and paper to give tuition, illustration and examples to students. Having a background in technology, I found it natural to make increasing use of a computer to create, develop and store demonstration materials. Its main benefits were the quality and consistency of the material and the facility of presentation. With the material already prepared, as a tutor I could focus my attention, and time, on the student's responses. I did not have to spend time drawing or redrawing diagrams and so there was less opportunity for distraction, which seemed to make it easier for the student to maintain focus on the subject and make efficient use of the student's attention span.

Some of the developments are now described.

1.2.1 Multiplication tables

By using a computer slide show I could enable a student to learn a multiplication table in approximately five minutes. Using the seven times table as an example, the method I used was this. I would start by showing a slide (Figure 1.1 a) and asking, what is seven times 2? When the student gave an answer, I would then show the next slide (Figure 1.1 b), which gave the correct answer. If necessary, this sequence was repeated until the student could give the correct answer.

The next part of the process repeats the previous part and adds the question, $7 \times 3 = ?$ The sequence of slides is shown in Figures 1.1 (a) to (d). If necessary this stage is repeated until both answers are correct.

The next part of the process repeats the previous part and adds the question,

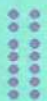

$7 \times 4 = ?$ If necessary this stage is repeated until all answers are correct. The process continues in this manner.

- $7 \times 2 = ?$
- $7 \times 2 = ? \ 7 \times 3 = ?$
- $7 \times 2 = ? \ 7 \times 3 = ? \ 7 \times 4 = ?$
- $7 \times 2 = ? \ 7 \times 3 = ? \ 7 \times 4 = ? \ 7 \times 5 = ?$
- $7 \times 2 = ? \ 7 \times 3 = ? \ 7 \times 4 = ? \ 7 \times 5 = ? \ 7 \times 6 = ?$
- $7 \times 2 = ? \ 7 \times 3 = ? \ 7 \times 4 = ? \ 7 \times 5 = ? \ 7 \times 6 = ? \ 7 \times 7 = ?$
- $7 \times 2 = ? \ 7 \times 3 = ? \ 7 \times 4 = ? \ 7 \times 5 = ? \ 7 \times 6 = ? \ 7 \times 7 = ? \ 7 \times 8 = ?$
- $7 \times 2 = ? \ 7 \times 3 = ? \ 7 \times 4 = ? \ 7 \times 5 = ? \ 7 \times 6 = ? \ 7 \times 7 = ? \ 7 \times 8 = ? \ 7 \times 9 = ?$
- $7 \times 2 = ? \ 7 \times 3 = ? \ 7 \times 4 = ? \ 7 \times 5 = ? \ 7 \times 6 = ? \ 7 \times 7 = ? \ 7 \times 8 = ? \ 7 \times 9 = ? \ 7 \times 10 = ?$

The first four and the final two slides used in the process are shown in Figure1.1.



What is

$7 \times 2 = ?$

(a)



$7 \times 2 = 14$

(b)

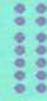

What is

$7 \times 2 = 14$
 $7 \times 3 = ?$

(c)



$7 \times 2 = 14$
 $7 \times 3 = 21$

(d)



What is

$7 \times 2 = 14$	$7 \times 6 = 42$
$7 \times 3 = 21$	$7 \times 7 = 49$
$7 \times 4 = 28$	$7 \times 8 = 56$
$7 \times 5 = 35$	$7 \times 9 = ?$

(e)

$7 \times 2 = 14$	$7 \times 6 = 42$
$7 \times 3 = 21$	$7 \times 7 = 49$
$7 \times 4 = 28$	$7 \times 8 = 56$
$7 \times 5 = 35$	$7 \times 9 = 63$



(f)

Figure 1.1: Seven times table, sequential

Once the student could recall the table sequentially, I would then use a similar slide show which presented the questions non-sequentially. Some of the non-sequential slides are shown in Figure 1.2. The method seemed to be effective in enabling a person to commit a multiplication table to memory within a few minutes. However, unless the student made use of the table they might not have been able to recall it a week later.

What is



$7 \times 7 = ?$

(a)

What is



$7 \times 2 = ?$	$7 \times 7 = 49$
------------------	-------------------

(b)

What is



$7 \times 2 = 14$	$7 \times 7 = 49$
$7 \times 5 = ?$	

(c)

What is

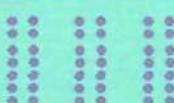

$7 \times 2 = 14$	$7 \times 7 = 49$
$7 \times 5 = 35$	$7 \times 9 = ?$

(d)

What is



$7 \times 2 = 14$	$7 \times 6 = ?$
	$7 \times 7 = 49$
$7 \times 5 = 35$	$7 \times 9 = 63$

(e)

What is

$7 \times 2 = 14$	$7 \times 6 = 42$
$7 \times 3 = ?$	$7 \times 7 = 49$
$7 \times 5 = 35$	$7 \times 9 = 63$

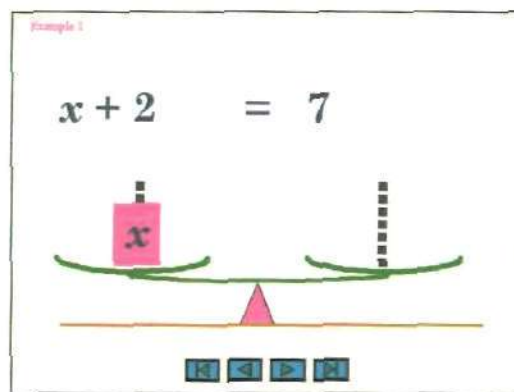



(f)

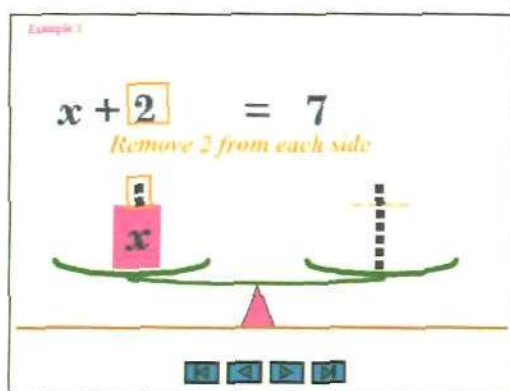
Figure 1.2: Seven times table, non-sequential

1.2.2 Solving equations

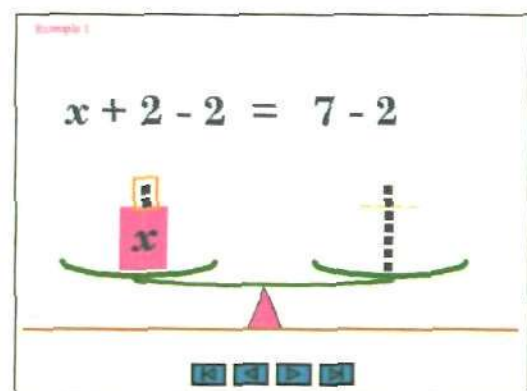
When students came to me for assistance with solving equations, I usually started by asking them to solve an equation similar to, $x+2 = 7$. The equation was displayed on a computer screen as shown in Figure 1.3 (a). Students usually gave the correct answer, but when asked what they did, they would say that the answer was obvious, or that the answer could not be other than five, in which case, I then asked them to solve the equation, $2x + 3 = 11$. If they answered this correctly but were still unable to explain how they did it, I would ask them to solve increasingly more complex equations. Unless students were consciously aware of their method, then usually they were unable to solve the second or third equation. My purpose in asking a student to solve a simple equation, before giving instructions on how to do so, was twofold. It demonstrated to them that they did have ability. For people who had completed secondary education with modest mathematical attainment, it seemed important to foster their self-confidence. It also encouraged them to analyse their own thought processes. I then used the computer to progress through the pictures shown in Figure 1.3.



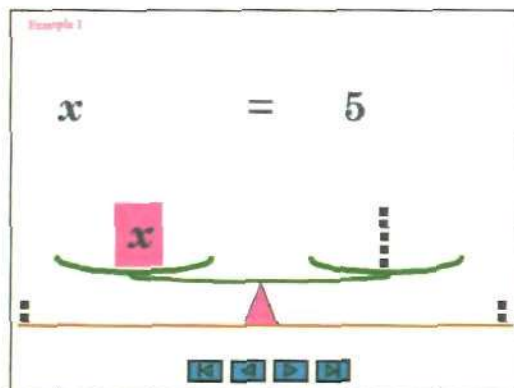
(a)



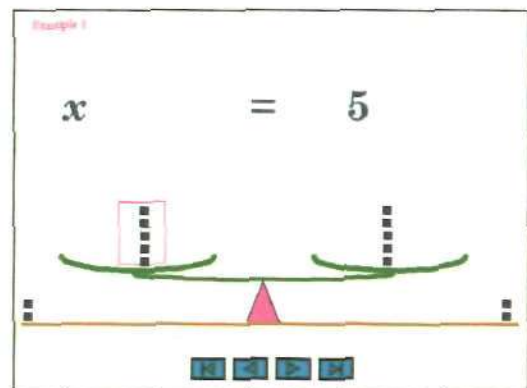
(b)



(c)



(d)



(e)

Figure 1.3: Sequence from computer slide show for solving an equation

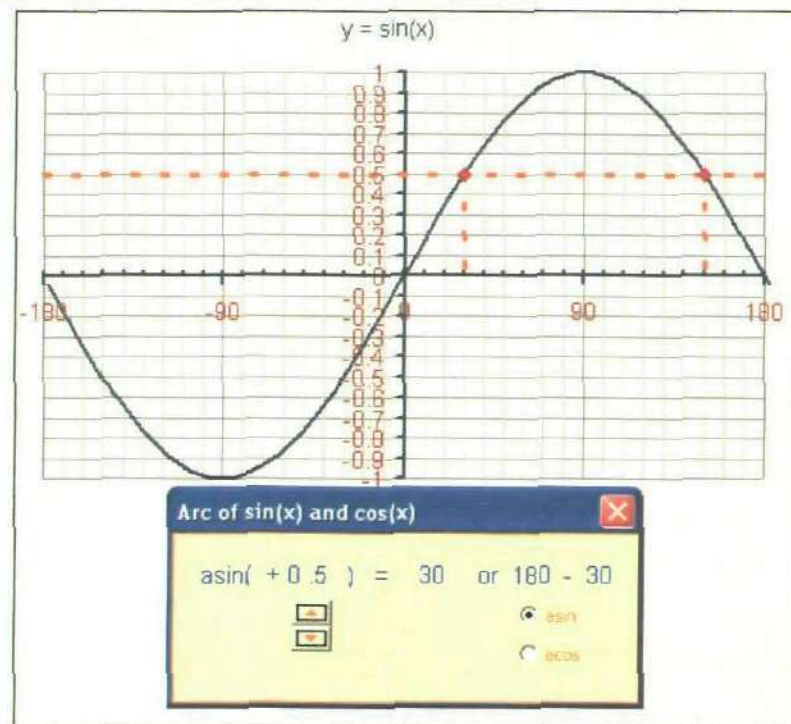
Before each new slide was shown the student was asked to anticipate what it would show. The solutions of two more equations, $2x + 3 = 11$ and $x - 2 = 6$,

were solved in the same way. By the completion of the third equation the student would usually recognise a method for solving equations. The method was consolidated by demonstrating the solution of other equations in a similar manner but without the scales. Again, it was important to ask the student to anticipate each step of the solution before it was revealed. Further consolidation was done using paper-based material relating to the student's vocational area.

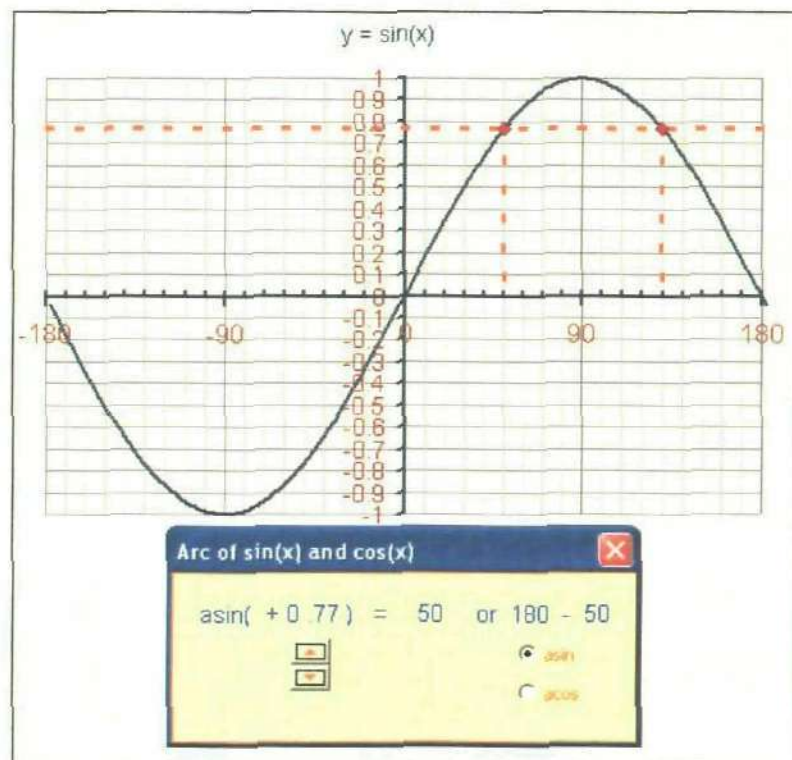
1.2.3 Trigonometry

Using a calculator to find inverse trigonometric functions with solutions not in the first quadrant was a problem for some students. A visual aid that seemed to help in this respect is shown in figure 1.4.

The student would be asked to use a calculator to find the sine of an angle in the second quadrant, e.g. $\sin(150)$. They would then be asked to use the calculator to find the inverse sine of the answer. The computer screen shown in figure 1.4 would then be used to resolve the apparent anomaly that $\sin(150) = 0.5$ while $\sin^{-1}(0.5) = 30$. On the computer screen $\sin(x)$ can be varied continuously between -1 and 1 to demonstrate that there are two possible values for $\sin^{-1}(x)$ and that they sum to 180° . Some students liked to think of two values, A and B, such that $A+B = 180$. Others preferred to think of two values, A and $(180 - A)$.



(a)



(b)

Figure 1.4: Inverse sine

1.3 Summary

From my experience in providing support in mathematics it seemed that many students in tertiary education lacked basic mathematical skills. There were gaps in their knowledge, for example the order of precedence of operations, and their grasp of concepts, for example fractions, was weak.

My experience seemed to indicate that there was potential in using technology to teach mathematics. However, what was successful with some students was not necessarily successful with others. What was also interesting were the preferred nuances of perception between different students, for example in the way the inverse sine function could be considered to yield two values, A and B that sum to 180 , or two values, A and $180 - A$.

From these considerations two general questions emerged;

- What is the problem with mathematics that seems to make even the basics inaccessible to many people?
- How can technology be used to address the problem?

Chapter 2: A review of relevant literature

2.1 Introduction

The purpose of this research is to assess the effectiveness of a particular use of technology to teach mathematics in the classroom. This purpose arises from the concluding questions raised in section 1.3, the Summary to Chapter 1.

In this chapter, concerns over the teaching of mathematics are identified from a number of sources. Consideration of the purpose of mathematics education leads to a consideration of the purpose of education in general. An examination is made of widening participation in higher education.

The latter sections of the chapter examine the use of computer-based technology in teaching and learning. Studies of the use of technology in the teaching of mathematics are discussed and consideration is given to the use of technology in relation to pedagogy.

2.2 Documented problems with mathematics education

2.2.1 National symptoms

Official concern over the state of mathematics education in England was expressed in 1982. It was reported that many pupils were being offered mathematics courses unsuitable to their needs and that many teachers of mathematics lacked suitable qualifications (Cockcroft 1982, p243). In 1977 approximately 30% of schools had only 50% or less of the mathematics curriculum 'suitably' staffed; approximately half (47.5%) of schools had only 60% of the mathematics curriculum 'suitably' staffed; only 5% of schools had the whole mathematics curriculum 'suitably' staffed and only 10% of schools

had more than 80% of the mathematics curriculum 'suitably' staffed (Cockcroft 1982, p258). Twenty-three years later the Smith Inquiry (2004) was unable to report a more optimistic situation.

The Inquiry notes with concern the Chief Inspector's view in 2001/02 that shortages of specialist teachers in mathematics are having an adverse effect on pupils' performance (Smith 2004, p21)

Respondents to the Inquiry corroborated this view (Smith 2004, p21).

We should not be surprised, therefore, by comments about decline in the standard of mathematics ability of entrants to higher education. (Savage, Kitchen, Sutherland and Porkess 2000; Egerton 2001; Pyle 2001). Smith (2004, p29, 152) makes recommendations to address the shortage of mathematics teachers in schools, Recommendation 2.2 (Smith 2004, p152) being to establish a strategy for the collection of data relating to mathematics teacher and teacher trainer numbers and qualifications. Clearly, it will be some time before benefits accrue from the implementation of these recommendations.

According to a report by the Engineering Council (Savage *et al.* 2000), mathematics teachers in Higher Education face serious problems because students do not have basic mathematical skills. In the Preface the Council states,

Evidence is presented of a serious decline in students [sic] mastery of basic mathematical skills and level of preparation for mathematics-based degree courses. This decline is well established and affects students at all levels. As a result, acute problems now confront those teaching mathematics and mathematics-based modules across the full range of universities (Savage *et al.* 2000, pii) .

The problem is not confined to the field of engineering. In the field of bioscience Tariq (2005, p4) refers to students' plight of being unprepared for the challenges and demands of higher education curricula. Reporting on an event attended by fourteen staff from ten higher education institutions she records a consensus opinion that students lacked confidence; were often fearful of anything mathematical; and lacked the ability to apply their skills and knowledge in specific biological contexts.

The Engineering Council (Savage *et al.* 2000, p2) report points to changes in the school curriculum in the 1970s which have caused a divergence between Secondary Education and the requirements of Higher Education. Significantly, however, changes in the knowledge content of the curriculum are not seen as an insuperable problem.

For the following decade, science and engineering departments learned to cope with students having varied backgrounds in Applied Mathematics. Indeed they were able to do so because Pure Mathematics at A level remained solid and students continued to be generally well prepared with regard to study skills, problem solving skills and basic mathematical capabilities (Savage *et al.* 2000, p2).

Further changes in the secondary school curriculum in the 1980's and 1990's produced problems that were more difficult to solve and led to high failure rates.

The GCE examination was replaced by GCSE which, for Mathematics, brought a decline in students [sic] concept of proof and in their technical fluency and understanding of algebra. At a stroke A level Mathematics was undermined in a key area from which it has not yet recovered! (Savage *et al.* 2000, p2).

The Engineering Council (Savage *et al.* 2000, p3) clearly identifies changes in the school mathematics curriculum which have produced students who are "unprepared (by earlier standards) for mathematics-based degree programmes." The words in parenthesis, "by earlier standards", are significant because they constitute an acknowledgement that standards have changed. If the entry standards have changed while the substance and aims of degree programmes have not changed, then anomalies can be anticipated. In its findings, the Engineering Council identifies possible reasons for the lack of preparedness in mathematics of new undergraduates.

Possible reasons for this include:

- changes in GCSE and A Level syllabuses and structures;
- greatly reduced numbers taking A level Mathematics and Further Mathematics
- changes in the teaching force and in society
- lack of practice and poor study skills

(Savage *et al.* 2000, p iii).

As the Engineering Council was looking at the problems facing students entering Higher Education it is perhaps natural that it should find reasons for these problems outside of Higher Education. Higher Education establishments, however, have responded positively to the problem.

We are at the stage where a number of individuals in various institutions are currently exploring a wide range of follow-up strategies. These include supplementary lectures, additional modules, computer assisted learning, Mathematics Support Centres, additional diagnostic tests and streaming (Savage *et al.* 2000, p 14).

Teacher training for university teachers is not included in these strategies. Laurillard (1997, p1) recognises pressures for change on universities and places a high priority on teacher training for university teachers.

Academics are going on courses on management training and marketing methods. Reform of an education system might be better served if they went on courses on how to teach better (Laurillard 1997 p1).

In support of this statement she recalls her first lecture as a university student, and her first lecture as a university teacher.

My first lecture as a student was a wretched experience. With 199 other students I counted myself lucky that I was in the main lecture theatre and not in the overspill room receiving closed circuit television. The lecturer was talking formulae as he came in, and for fifty minutes he scribbled them on the board as he talked and we all scribbled more in a desperate attempt to keep up with his dictation.(Laurillard 1997, p1)

My first lecture as a teacher was no better...one brave student asked a question of such breathtaking 'stupidity' that it was clear he could not have understood anything beyond my first sentence. Did anyone else have the same problem? Yes, they all had that problem (Laurillard 1997 p1).

In 2000 the Learning and Teaching Support Network (LTSN) for Mathematics, Statistics and Operational Research (MSOR) was established. Its mission statement is

"to promote high standards in the learning and teaching of Maths, Stats and OR by encouraging staff development, knowledge exchange, innovation and enterprise, leading to an enhancement of the learning experience for students, from school through university to the workplace" (MSOR 2005).

For its own staff and staff at partner colleges, the University of Plymouth offers a modular programme leading to the award of Postgraduate Certificate in Learning and Teaching in Higher Education (University of Plymouth 2006).

The Engineering Council report identifies one of the reasons for the problem as "changes in the teaching force and in society;" (Savage *et al.* 2000, p iii) but specifically finds no fault with teachers in schools. The changes in society are not quantified but significant changes in schools are acknowledged.

Compared to their predecessors, they have to deliver a different curriculum, under very different and difficult circumstances, to quite different cohorts of students (Savage *et al.* 2000, p iii).

Similar problems are identified in America by Picker (Picker 2000), who suggests a possible effect on teachers' behaviour as a result of such changes.

The demands on teachers to cover expanded curriculum content, may also cause them to do students' thinking for them (Picker 2000, p 48).

My own observations in Chapter 1 that some students appeared not to expect to understand could be a consequence of such behaviour by teachers.

As a part of society, universities can expect to experience effects from changes in society. Response to any change depends on whether the change is seen as desirable or undesirable. The recommendations of the Engineering Council (Savage *et al.* 2000, p iv) are in line with its findings and, by excluding specific proposals for change in the delivery and aims of Higher Education, suggest that the Council is not in agreement with these undefined changes in society.

Graham (2002) identifies a number of issues relating to the implementation of AS Mathematics. The first reformulated AS level examinations took place in 2001. Under the new system it was intended that year 12 students would study 5 subjects to AS Level. In year 13 they would continue with 3 of these subjects to A level. The purpose of the new system was to encourage breadth of study without sacrificing depth. While acknowledging a potential benefit of the new structure that may encourage more students to study mathematics he expresses "alarm" that, by choosing particular options, substantial numbers of students do not cover content prescribed by the QCA subject criteria for mathematics. Consequently, their level of achievement will not meet the requirements of universities or employers.

There is a suggestion from Kent (2002) that the mathematics taught on civil engineering degree courses is no longer relevant and in need of review.

Egerton (2001) acknowledges the mathematics problem cited by the Engineering Council (Savage *et al.* 2000). She also acknowledges inadequacy in the guidance and support (in mathematics) provided to first year students in higher education. White (2002) of Bath University describes a local initiative which aims to ease the transition from secondary/tertiary to higher education for students of mathematical sciences. She reports "genuine collaboration" between the different education sectors.

2.2.2 Summary

Some school leavers are daunted by mathematics and lack confidence in applying basic mathematical skills (Savage *et al.* 2000, p2).

It would seem that in the past, well-prepared students have been able to succeed in Higher Education even if there have been deficiencies in the teaching. Intentional changes in the Secondary Education curriculum have necessitated changes in the interface between the Secondary Education sector and the Higher Education sector. It appears that the role of Secondary Education has changed but the role of Higher Education has not, in which case it should not be surprising if incompatibilities arise at the interface between the two sectors. This raises the question of whether changes to the interface are sufficient, or whether adjustments are necessary and/or desirable in the aims of Higher Education.

These issues might be addressed by the fourth recommendation of the Engineering Council.

In order to develop and monitor a mathematical education that is (i) appropriate to the needs of the 21st century and (ii) fully integrated from primary through to tertiary levels, the Government should establish a Standing Committee for Mathematics to include representatives from all sectors and stakeholders (Savage *et al.* 2000, p iv).

2.3 Mathematics education

2.3.1 The nature of mathematical knowledge

It has been argued that knowledge does not exist as a definable object independent of the knower (Ernest 1995, p 3) and does not have fixed properties of its own. My counter argument to this is that a graph of a quadratic function has definable properties whether people know about them or not; it has a turning point which lies on its axis of symmetry; it crosses the

vertical axis at a point defined by its constant term; whether and where it crosses the horizontal axis is determined by the coefficients of its other terms.

The primary argument may assert that a graph of a quadratic function is not knowledge: it is an object: knowledge of an object is personal to the knower.

a mathematical truth is not dependent upon the contingencies of adult society but upon a rational construction accessible to any healthy intelligence; an elementary truth in physics is verifiable by an experimental process that is similarly not dependent upon collective opinions but upon a rational approach, both inductive and deductive, equally accessible to that same healthy intelligence(Piaget 1971 page 26).

It is not intended in this thesis to debate the nature of knowledge. In agreement with Piaget (1971 page 26) it is accepted that there are mathematical truths which are not dependent on the knower.

2.3.2 The purpose of mathematics education

The National Curriculum (DfEE 1999) recognises the importance of mathematics in everyday life and in public decision-making.

Mathematics equips pupils with a uniquely powerful set of tools to understand and change the world. These tools include logical reasoning, problem-solving skills, and the ability to think in abstract ways. Mathematics is important in everyday life, many forms of employment, science and technology, medicine, the economy, the environment and development, and in public decision-making (DfEE 1999).

A similar statement is found in the 2001 yearbook of the National Council of Teachers of Mathematics

In a vital democracy, a primary goal of schooling should be the development of thoughtful, informed, and active citizens. Mathematics is an indispensable tool for reaching this goal (Abrams 2001 page 269).

This sensible and rational view finds support from diverse sources. According to Piaget (1971, p124) the role of education is the training of "inventive and critical minds". In an essay in support of a classical education Daniel (2003) states,

The purpose of education is rather to furnish and order a mind such that information can subsequently lodge there, to create understanding, for what is understood remains whilst nonsense is ephemeral (Daniel 2003).

Daniel (2003) supports the study of traditional subjects but sees relationships among them. He points to the benefits that individual subjects contribute to education. Of mathematics he says,

So too the study of mathematics engenders a sense of shape and proportion, of cause and effect and of (largely fictitious) probability which endures long after we have forgotten the formula for quadratic equations or the value of pi (Daniel 2003).

According to the 17th century writer and philosopher, Francis Bacon, study of mathematics serves the development of subtlety (Pritcher 1985, page210). Subtlety, however, is only part of a person's character and development of the whole character requires a broad range of study. Bacon's essay, "Of Studies" (Pritcher 1985, page 209) anticipates ideas expressed by Bloom (1956) in his taxonomy of cognitive skills, which has correspondence with the concepts of 'instrumental understanding' and 'relational understanding' put forward by Skemp (1976). At the lowest level of Bloom's taxonomy of cognition is

knowledge. The higher levels are, respectively; comprehension; application; analysis; synthesis and evaluation (Bloom 1956). Skemp (1976) describes instrumental understanding as rules without reasons. Relational understanding is knowing both what to do and why. Bacon's advice to the reader implies development of relational understanding and the higher level cognitive skills.

Read not to contradict and confute; nor to believe
and take for granted; nor to find talk and discourse;
but to weigh and consider (Pritchard 1985).

Another supporter of wider education is Dr Robert Hawley, current Chairman of Taylor Woodrow plc and past president of the Institution of Electrical Engineers. Hawley (2003) argues that broadening the base of engineering education will enhance, or perhaps enable, students' creativity and that those who study the arts and humanities also need a basic understanding of science. Future developments in technology, he asserts, will require partnerships between creators and users. In making recommendations for the development of higher education, Robbins (1963, p8) considered as guiding principles that education serves to "develop a [wo/]man's capacity to understand, to contemplate and to create"; and that any society would want its citizens to be "not merely good producers but also good men and women" (Robbins 1963, p8).

In the field of bioscience some practitioners consider that, associated with specific disciplines, there is essential mathematics which students need to understand and master (Tariq 2005). A problem solving approach is advocated in order to achieve "deep learning."

The views of Hawley (2003) and Tariq (2005) are compatible with that of Laurillard (1997).

The point of an academic education is that knowledge *has* to be abstracted, and represented formally, in order to become generalisable and therefore more generally useful...concepts need to be grounded in experience and practice before they can be abstracted (Laurillard 1997 page 19/20).

Although Laurillard's (1997) book is about the teaching of mathematics, her statement about the point of an academic education implies that the study of mathematics is part of a wider education. Daniel (2003) rejects emphatically that the primary purpose of education should be vocational.

The prejudice against so-called "dead" languages is founded upon a grave misconception - to wit, that education should serve a demonstrably useful vocational purpose. That is the function of apprenticeship (Daniel 2003).

He is dismissive of any notion that education can be measured from the volume of information that may be imparted.

The imparting of information is merely an incidental. Few of us use or even recall a modicum of the information so laboriously amassed at school. The hours currently devoted to training our children in IT, for example, are, quite simply, time wasted. By the time that they are full-grown, IT will have been transformed (I trust) and anyone with an orderly mind can pick up the required skills in mere days (Daniel 2003).

Similarly Piaget (1971, p82) rejects the idea that success in education can be measured quantitatively, and refers to "intolerable overloading of educational programs" (Piaget 1971, p96).

Cohen et al (2001, p34) outline the argument that modular competence-based curricula reflects the "commodification, measurability and trivialisation of curricula..." Concerns of this nature are not new. In the nineteenth century Dickens (1994)¹, through his novel, *Hard Times* (Dickens 1994)¹, expressed similar concerns.

Now what I want is, Facts. Teach these boys and girls nothing but Facts. Facts alone are wanted in life. ... Stick to the Facts, Sir! (Dickens 1994 p1)¹
Thomas Gradgrind now presented Thomas Gradgrind to the little pitchers before him, who were to be filled so full of facts. (Dickens 1994 p2)¹

Dickens' novel parodies the Monitorial System (or perhaps its implementation rather than the system itself) developed by Joseph Lancaster in the 19th century. His main criticism of the system seems to be that it treats learners as empty vessels to be filled with facts. Norton et al (2000) appear to have found similar attitudes when conducting research in a private girls school in the 20th century.

They had accepted that getting students to "Jump through hoops" was part of their responsibility as **teachers**. Peter stated, "assessment is what we are about ... My teaching is geared towards assessment." Eva carefully drilled the rules and algorithms that would be on the next examination and explained that "algorithms are very important since everything is based upon those algorithms (Norton et al. 2000).

¹ 1854 in 'Household Words'

Norton et al (Norton *et al.* 2000) provide a brief insight into mathematics teaching at a particular school and the comparison with Dickens's novel is not intended to infer a lack of educational development over two centuries. In Dickens' novel, education is wholly the transfer of knowledge and the role of the teacher is absolute. In the mathematics classes observed by Norton et al (2000) transfer of knowledge and skill was paramount and the role of the teacher was dominant.

Peter, Eva and Emm all liked tight control over their students' activities and insisted on compliance and obedience. ... In their classes, the teacher did almost all of the talking and students were limited to very precise responses. Peter and Emm liked to decide what skills and activities were appropriate for their students to such a degree that they both decided it was inappropriate for the students to be exposed to mathematical software (Norton *et al.* 2000).

The findings of Norton et al (2000) support the opinion of Laurillard (1993), which raises the question of what is being achieved by formal education.

Mastery of the art of taking examinations designed to test knowledge is more prevalent than mastery of the knowledge itself (Laurillard 1997).

The concern is over what learning activities can be regarded as constituting education. Dickens (1994) and Norton (2000) describe activities which are compatible with the first level of Bloom's Taxonomy (Bloom 1956, p 18): the acquisition of factual knowledge; stating, defining, recalling and describing. It can be reasoned that learning activities that develop the lower levels of the taxonomy constitute training, whereas education should comprise activities that develop all levels of the taxonomy. There may be a tension between whether certain learning activities should be regarded as training or as

education. Formal categorisation of learning activities as education or training would not be helpful in this thesis, the purpose of which is to consider how technology can be applied appropriately to assist learning.

Dickens's parody of nineteenth century education appears still to have relevance today. His following quotation describes education that is limited to the lower levels of Bloom's Taxonomy (Bloom 1956), knowledge, comprehension, and application: the higher levels, analysis, synthesis and evaluation are precluded.

Herein lay the spring of the mechanical art and mystery of educating the reason without stooping to the cultivation of the sentiments and affections. Never wonder. By means of addition, subtraction, multiplication, and division, settle everything somehow, and never wonder (Dickens 1994).

This is in stark contrast to current thinking on the aims of education as advocated by Biggs (2003) and Petty (1998). Both of these authors argue convincingly that education should be concerned with much more than the acquisition of facts and information. Petty (1998, p346) encourages development of the skills of analysis, synthesis and evaluation. Biggs (2003, p9) advocates teaching methods that require and/or encourage the student to engage in "higher cognitive level processes", such as relating, applying and theorizing.

The committee appointed in 1961 (Robbins 1963, piii) to review the pattern of full-time higher education in Great Britain considered that it was undertaking the first-ever comprehensive survey of higher education in the United Kingdom (Robbins 1963, p4). The committee saw two significant changes in circumstances that necessitated the survey. Firstly, the universities had

become dependent on funding from the state. Secondly, the academic level of many courses delivered by other colleges was considered to be on a par with degree courses offered by the universities, bringing to an end the universities' role as sole providers of higher education at degree level.

While the committee commended separate, independent initiatives, it considered that it was in the national interest to establish a coordinated system of higher education. It was, however, emphatic that it was not demanding central planning and control of institutions; freedom of individuals and institutions was highly valued.

Rejecting any idea that the purpose of higher education could be summarised in a single objective or described by a simple formula, the committee outlined four broad objectives which they considered essential and minimal (Robbins 1963, p6-7).

- Whatever is taught should be taught in a way conducive to the development of "cultivated men and women", who are able to apply their skills and knowledge generally.
- Students should be able to acquire skills relevant to the national economy and industry.
- The advancement of learning: research
- Institutions contribute to the general cultural life of the communities in which they are situated.

For Robbins, it is acceptable and not contradictory that higher education should provide students with opportunities to develop utilitarian skills and at

the same time “promote the general powers of the mind” (Robbins 1963, p6). Today, Tomlinson (2004, p86) agrees with this, stating that, “There is no absolute distinction between vocational and general (or academic) learning”. Under the heading of “Academic freedom and its scope” Robbins (1963, p228) balances the needs of the individual and the institutions with the responsibility of the Government to ensure that the development of higher education is adequate to national needs.

In recommending vast expansion of higher education, Robbins acknowledged that this expansion would require to be given priority in the allocation of national resources. This he defended as essential “for the realisation in the modern age of the ideals of a free and democratic society” (Robbins 1963, p265-267). In the next section we look at the increasing numbers participating in higher education.

2.4 Widening participation

Between 1971 and 2001 the number of undergraduate enrolments in United Kingdom institutions of higher education increased by approximately 170% (DfES 2001). Over the same period the total population of the United Kingdom changed by only a few percent (ONS 2001, spreadsheet). In 2003, 43 percent of 18-to-30 year olds were participating in higher education in England and Wales (DfES 2003a, p57), and it is the policy of the United Kingdom Government to increase this figure towards 50 per cent by the year 2010 (DfES 2003a, p57). In the first half of the 20th century there was a steady increase in the numbers participating in higher education (Robbins 1963, p15 table 3). Figure 2.1 below shows the numbers of full time students in higher education for the whole of the 20th century. It has been compiled from data

from the Robbins report (Robbins 1963, p15 table 3) and data from the Department for Education and Skills (DfES 2001).

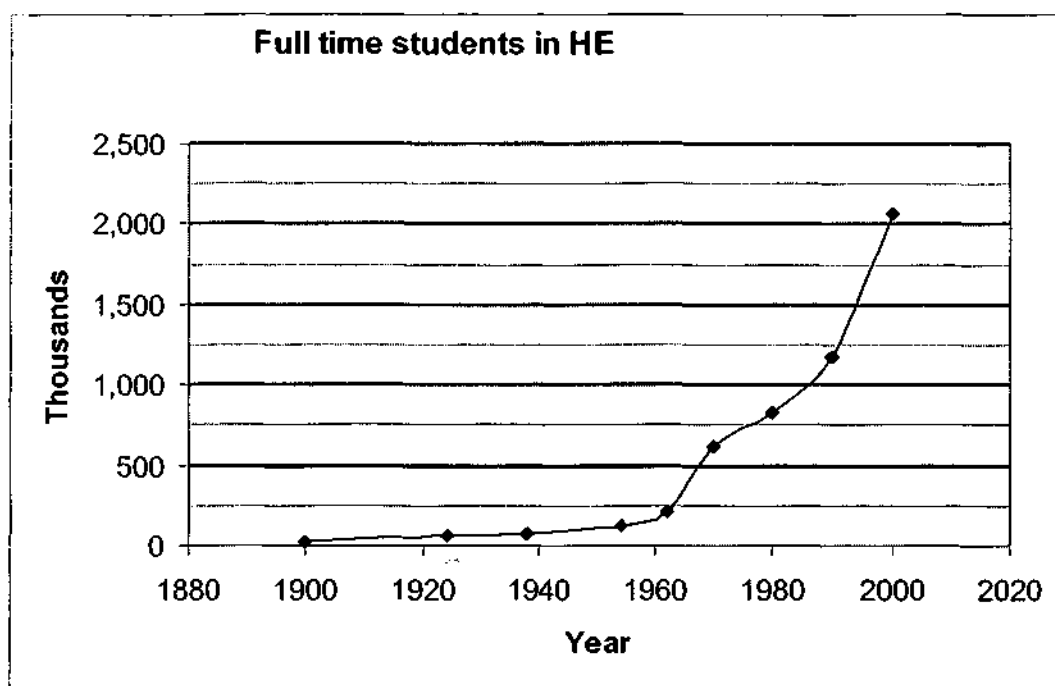


Figure 2.1: Growth in number of students in Higher Education

Given this dramatic rise, over the last thirty years of the 20th century, in the proportion of the population participating in higher education, perhaps it should not be surprising if uncertainties arise in the compatibility between the education system and the students.

Assuming that any selection process (for whatever purpose or establishment: school, sports team, employment, government) selects the most able and/or suitable, then, if the selection process is changed and a greater proportion of the population is admitted, the average (mean or median) ability of the entrants must decline. Unless the establishment to which increased numbers have been admitted makes some change in its behaviour to accommodate the lower average ability, then it would not be surprising if the average

achievement of the alumni also declined. This argument assumes that achievement is a function of ability and that both are quantities that can be measured. Many (Piaget 1971; Skemp 1976; Pritcher 1985; Laurillard 1997; Hawley 2003; Watson and De Geest 2005; Webb 2005) reject the idea that success in education can be measured by quantity. The underlying principle of the argument, however, is sound: changing the input to a system, while keeping the system constant, can be expected to cause a change in the output. Piaget acknowledges this and sensibly advises that if the number entering education is deliberately increased then thought must be given to the future; the structures which are currently appropriate are unlikely to remain appropriate (Piaget 1971, p86).

In the case of mathematics education, the general problem, of developing the system to accommodate a greater proportion of the population, is exacerbated by problems discussed in this chapter.

Smith (2004, p153-156) makes recommendations on curriculum content, delivery and assessment. In developing these recommendations, Smith (2004, p96) puts forward the idea that education needs to be adapted to the needs, if not of the individual learner, then of a range of learners with differing characteristics.

not all learners learn in the same manner, or at the same speed, or respond positively to the same styles of assessment (Smith 2004, p96).

This resonates with Biggs' (2003, p20-22) concept of constructive alignment and with Piaget's (1971, p137) description of teaching methods which take into account the nature of the learner.

Smith (2004, p97) also suggests that new approaches to pedagogy and the employment of ICT should be guiding principles in the construction of possible future pathways for mathematics in schools. Tomlinson (2004, p92-94), concerned that "too many young people are turned off learning and fail to achieve between 14 and 19", devotes a chapter to proposals intended to make education more relevant and appealing to this group. Higher education too is intended to respond to the needs of a wider section of the population.

As more people from non-traditional backgrounds go into higher education we must make sure that they are well-served when they get there (DfES 2003a, p63).

Through the Qualifications and Curriculum Authority (QCA), the Government set up the Post-14 Mathematics Inquiry (Smith 2004). This inquiry invited responses to a wide range of questions and issues including government's policy and strategy, and the curriculum. The terms of reference of the report were,

To make recommendations on changes to the curriculum, qualifications and pedagogy for those aged 14 and over in schools, colleges and higher education institutions to enable those students to acquire the mathematical knowledge and skills necessary to meet the requirements of employers and of further and higher education (Smith 2004, p2).

Tomlinson (2004, p96) asserts that actively involving individuals in discussion on the effectiveness of the teaching/learning process is not only appropriate but is also conducive to the development of wider attributes and skills. Learners are best served by consulting them.

2.4.1 Teaching and learning

Berry and Sharp (1999) describe a student-centred model for university level mathematics modules. They express concern that the nature of mathematics teaching in schools is essentially transmissive, what Biggs (2003) would describe as Level 1: teachers transmit their knowledge to students; learning is a function of the student's ability. They sought to develop a delivery style of teaching/learning that was

- more student active, less staff active;
- co-operative between student, and student and staff;
- constructive in the sense that students develop their own knowledge, skills and understanding from their own mathematical activities;
- reflective, in the sense that each student sees the approach of their peers and compares with their own (Berry *et al.* 1999, p30).

Biggs (2003) describes this type of teaching as Level 3; learning is a function of what the student does; characteristics of the student, characteristics of the environment and characteristics of the teacher all influence what the student does. Berry and Sharp (1999) were attempting to achieve what Biggs (2003, p20-22) would now describe as Constructive Alignment, a design for teaching calculated to encourage deep engagement of students with the subject. Berry and Sharp assessed the student's initial concept of learning on a scale of seven "steps to good learning," (Berry *et al.* 1999) comparable with Bloom's (1956) taxonomy of cognitive learning skills. While they found it encouraging that the majority of the group recognised the value of co-operation and discussion, they draw attention to the consensus belief of the cohort that the teacher plays a dominant role in their learning. They suggest that this belief

gave rise to significant apprehension among the group, and even hostility in one student, as the teaching style employed is opposed to this belief. A post-module questionnaire showed that the cohort recognised the positive aspects of the style of delivery. The student who initially had been hostile, describing the delivery style as "trendy teaching" is quoted as stating in the post-module questionnaire, "I think the style was beneficial".

Biggs (2003) cites two quotations at the start of his book to remind us that learning takes place through the engagement of the student in the learning process. The teacher can assist and support the engagement, but what is learned is determined by the quality and strength of the engagement of the student: essentially, what the student does is more significant than what the teacher does. The need to engage the student is echoed by Petty (1998, p133) who cites a survey conducted in the 1930s to corroborate his assertion that the ability to explain things is a characteristic which students value highly in a teacher. This reasoning is affirmed by Piaget (1971).

If we desire, in answer to what is becoming an increasingly widely felt need, to form individuals capable of inventive thought and of helping the society of tomorrow to achieve progress, then it is clear that an education which is an active discovery of reality is superior to one that consists merely in providing the young with ready-made wills to will with and ready-made truths to know with (Piaget 1971, p 26).

All of these authors, Biggs (2003), Petty (1998) and Piaget (1971) recognise and deprecate the possibility that education can be seen simply as the acquisition of knowledge. Piaget (1971, p137) recognises this as the "old" or "traditional" methods of education. He acknowledges that education of children

involves inducting them to an adult social environment and consequently he identifies two factors of the education process, the individual, and the values of the society into which the individual is entering. "Traditional" methods of education he criticises as "mere transmission of collective social values from generation to generation" (Piaget 1971, p137). The educator was concerned with the outcome of education but not with the means or techniques of achieving the outcome. Education treated the child "as a little man to be instructed, given morals, and identified as rapidly as possible with its adult models" (Piaget 1971, p137). He describes 'new' methods as taking into account the individual nature of the child.

Corresponding with the above viewpoint, Biggs (2003, p20-22) identifies three levels of teaching. Level 1 requires that teachers know their subject well and transmit their knowledge to students. Learning is a function of the student's ability. At Level 2 the onus for students' learning shifts from the students to the teacher. Teaching technique and class management skills are paramount. The third level, to which we are encouraged to aspire, recognises that learning is a function of what the student does, and what the student does is influenced by characteristics of the student, characteristics of the environment and characteristics of the teacher. These interactions, between the student, the teacher and the environment in which the learning takes place, all have a bearing on learning outcomes. Student achievement is maximised when all three of these factors are working in harmony with each other. Biggs (2003, p9) defines this harmony as "Constructive Alignment".

While the idea is evidently supported that education should be concerned with development of the "higher cognitive level processes" (Biggs 2003, p9), simple

transmission of knowledge cannot be excluded from the education process. Piaget (1971, p78) asserts that "every discipline must include a certain body of acquired facts" and observes (Piaget 1971, p137/8) that it is just as natural for a child to be passively receptive as to be actively enquiring. He does not suggest an equal balance between passivity and activity; neither does he suggest equivalence between them; only that passivity and activity are both natural.

Acquisition of facts is not the same as assimilation of concepts. Skemp (1976) makes a distinction between "instrumental understanding" and "relational understanding". Piaget (1971, p26) contrasts the acquisition of facts with "a process of research and discovery during the course of which the human intelligence affirms its own existence and its properties of universality and autonomy", and questions whether "educational methods of transmission" are appropriate for the latter.

Similarly, Petty (1998, p127) commends the ability to explain but warns against the danger for teachers of relying too much on speech to deliver a lesson. The disadvantages he lists include that retention of information delivered orally is low; and that the average concentration span of students is shorter than for other methods of delivery.

Figure 2.2 (Biggs 2003, p8) illustrates that academically oriented students can be stimulated by passive teaching methods while less academically oriented students require active teaching methods.

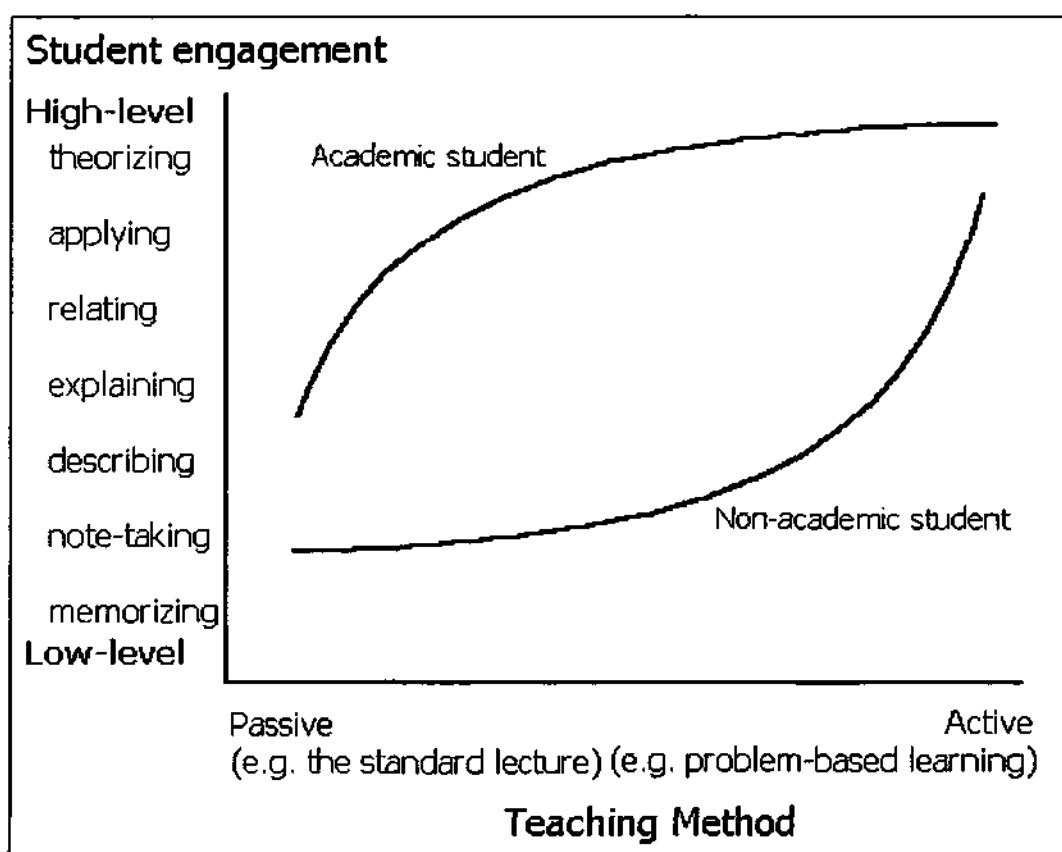


Figure 2.2: Student engagement vs teaching methods (Biggs 2003, p8)

Some students are academically oriented and spontaneously exercise the higher levels of engagement. Others need more support to develop their use of the higher levels of engagement in learning. It is not a simple matter of teachers learning new techniques. What is effective in one situation may not be effective in another. This was a conclusion of a United Kingdom Government inquiry in the teaching of mathematics (Cockcroft 1982, p71). The committee of inquiry specifically declined to indicate any definitive style for the teaching of mathematics stating that it is neither desirable nor possible to do so. Teaching, in the committee's view needs to be related to the abilities and experience of both teachers and pupils. They do, however, identify certain elements which they believed necessary for successful teaching of mathematics to "pupils of all ages". These elements are exposition by the

teacher; discussion between teacher and pupils and between pupils themselves; appropriate practical work; consolidation and practice of fundamental skills and routines; problem solving, including the application of mathematics to everyday situations; and investigational work.

Reflection, as a necessary component of the process of learning is referred to by Laurillard (1997, p215). Honey (1992) recognises reflection as an integral part of the learning process, which he describes as a continuous cycle of action, reflection, theorising and pragmatising. It is perhaps unfortunate that he also uses the term, "learning style" to refer to each of these components, as this may be taken to imply that these component activities are alternatives which different people can employ in their learning. From his book, (Honey 1992), it is clear that any particular person may incline more naturally to one component of the cycle than another. His readers are advised that effective learning requires completion of the cycle, and they are encouraged to develop the use of any non-preferred component(s). 'Learning preference' may be a more accurate term than 'learning style'. If effective learning requires utilisation of all components of the cycle then any pedagogy based on the 'learning style', the component of the cycle preferred by the learner, must necessarily be deficient. Pedagogy must also take into account the nature of what is to be learned. It is possible that, depending on the nature of what is being learned, the learning cycle may be dominated by one component. One can perceive that the learning of concepts may require considerable reflection, while the learning of processes may require considerable activity, or practice. It is also conceivable that different individuals may require to spend different amounts of time in any stage of the cycle to learn the same thing. Individuals

can also adapt to a situation. Having a preference for activity does not imply an inability to theorise. Mays and de Freitas (2005) advise caution in the promotion of learning styles as a basis for pedagogy because identification of learning style is "elusive" and it is unjustified to expect that learners display "enduring preferences and patterns of learning in all situations". Chinn and Ashcroft (2005, p14-24) describe a learning cycle with three components; analysing and identifying the problem; solving the problem; and checking and evaluating. They also refer to "cognitive style" which describes how a learner progresses through the learning cycle. They consider that awareness of a range of cognitive styles is essential for effective teaching of a broad spectrum of learners. Cognitive style, as shown in table 2.1 provides more useful detail within the learning cycle. The two extremes of the continuum of cognitive styles are the 'inchworm' and the 'grass-hopper' (Chinn and Ashcroft 1998, p18). The characteristics of each are shown in table 2.1. Clearly there are going to be occasions when the grasshopper approach will be more effective than the inchworm approach and vice versa. The job of the teacher is to develop a pedagogy that will take account of students' possible behaviours and the nature of the intended learning and elicit appropriate responses from the student. Webb (2005, p708) draws attention to research findings that misconceptions held by the participating students were not influenced by formal teaching. It was found that students would learn by rote a taught concept, but still retain their own misunderstanding of it. Pedagogies which promote conceptual change are reviewed by Webb (2005, p708-713). The essential nature of these pedagogies is Socratic: the main interaction between the student and the teacher is discussion in which the student is encouraged to think.

	Inchworm	Grasshopper
Analysing and identifying the problem	<p>Focuses on the parts and details. Separates.</p> <p>Looks at the numbers and facts to select a relevant formula or procedure.</p>	<p>Tend to overview, holistic, puts together</p> <p>Looks at the numbers and facts to estimate an answer and to restrict range of answer. Controlled exploration.</p>
Solving the problem	<p>Formula, procedure oriented.</p> <p>Constrained focus. Uses a single method.</p> <p>Works in serially ordered steps, usually forward. (Rifle).</p> <p>Uses numbers exactly as given.</p> <p>More comfortable with paper and pen. Documents method.</p>	<p>Answer oriented.</p> <p>Flexible focussing. Methods change.</p> <p>Often works back from a trial answer. Multi-method (Shot gun).</p> <p>Adjusts, breaks down/builds up numbers to make an easier calculation.</p> <p>Rarely documents method. Performs calculation mentally.</p>
Checking and evaluating	<p>Unlikely to check or evaluate answer. If check is done, uses same procedure or method.</p> <p>Often does not understand procedure or values of numbers. Works mechanically.</p>	<p>Likely to appraise and evaluate answer against original estimate. Checks by alternate method.</p> <p>Good understanding of the numbers, methods and relationships.</p>

Table 2.1: Cognitive styles (Chinn *et al.* 1998, p19)

2.4.2 Summary

2.4.2.1 The nature of mathematical knowledge

In this thesis we adopt the view of Piaget (1971, p26) that mathematical knowledge exists independently of the knower.

2.4.2.2 The purpose of mathematics education

Mathematics education is part of a wider education and there is a wide consensus (Bloom 1956; Piaget 1971; Skemp 1976; Cockcroft 1982; Pritcher 1985; Laurillard 1997; Chinn *et al.* 1998; Petty 1998; Berry *et al.* 1999; Biggs 2003; Daniel 2003; Hawley 2003; Smith 2004; Tariq 2005; Watson *et al.* 2005; Webb 2005) that education should be concerned with the development of skills such as analysis, synthesis and evaluation. Underlying these skills is the acquisition of knowledge. While the ability to recall knowledge is undoubtedly useful and has a place in education, by itself it would define a very unambitious goal for education, leaving higher cognitive abilities undeveloped and potential unfulfilled.

Education is for the benefit both of the individual and of the society of which the individual is part. This thesis does not consider conflict between the individual and society. It is assumed, perhaps idealistically, that society values individuals who have inventive and critical minds and is tolerant of non-conformity to tradition.

2.4.2.3 Widening participation

Since the 1970s the numbers participating in education at all levels have increased. Widening Participation, a current government initiative (DfES

2003b), actively encourages students from socio-economic backgrounds which traditionally would not provide entrants to Higher Education.

The changing student profile must make changing demands on the education system. This may in some way contribute to the concerns expressed by Savage *et al* (2000), and Tariq (2005).

2.4.2.4 Teaching and learning

While there is evidence of support for the view that the purpose of education is to develop the higher cognitive skills (Bloom 1956; Piaget 1971; Skemp 1976; Cockcroft 1982; Pritcher 1985; Laurillard 1997; Chinn *et al.* 1998; Petty 1998; Berry *et al.* 1999; Biggs 2003; Daniel 2003; Hawley 2003; Smith 2004; Tariq 2005; Watson *et al.* 2005; Webb 2005) there is evidence of practice which neglects them and which is confined to exercising lower cognitive skills (Piaget 1971; Skemp 1976; Dickens 1994; Laurillard 1997; Norton *et al.* 2000; Cohen *et al.* 2001; Tariq 2005).

There is evidence (Cox and Webb 2004, p258/9) of the development of pedagogies to address the development of the higher cognitive skills. Essential aspects of this development are that the student has greater influence on the pace and content of learning sessions and that the role of the teacher becomes less dominant, but remains crucial. The teacher must establish intended learning outcomes and guide students towards them. Although intended outcomes may well include or imply the recall of information, the formation of concepts is the overriding aim. The teacher is not solely a provider of information, but has to stimulate discussion and reflection appropriate for the development of concepts and the correction of any

misconceptions. It is suggested that this type of pedagogy leads to the student taking greater onus for his/her learning and consequently gaining in confidence. Learning is more effective when teachers fulfil role models rather than act as fountains of knowledge. Teachers and students need to establish an environment of mutual respect where students take onus for their own learning.

2.5 Use of Information and Communication Technology (ICT) in education

2.5.1 The case for using technology

The United Kingdom Government's commitment to the use ICT in schools is confirmed in a report.

The ICT in Schools programme (formerly the NGfL programme) is the Government's key initiative for improving ICT provision in schools, developing a wide range of digital resources for teaching and learning and equipping teachers to be effective users of ICT. The programme underpins the Government's vision for transforming education. (DfES 2002, p21).

The Smith Report, Making Mathematics Count (Smith 2004, p133,134), acknowledges the role of Information and Communication Technology (ICT) in the support of the teaching and learning of mathematics, noting that Learning and Teaching Support Networks (LTSNs) have considerable experience in the electronic delivery of materials aimed at enhancing learning and teaching in mathematics. The enquiry, however, was unable to identify any clear audit of the availability and use of ICT to support the teaching of mathematics, and recognised the need to understand the current position with regard to the

availability of ICT resources, to encourage appropriate use of currently available resources and to identify high quality software. A report from the British Educational and Communications Technology Agency to the Learning and Skills Council states that "in most colleges ... electronic learning materials are not extensively used". (BECTa 2004, p3). Smith (2004) makes the following recommendations.

The Inquiry recommends that the remit of the new national support infrastructure include the responsibility for auditing existing ICT provision for mathematics in schools and colleges, assessing the need and potential for future ICT provision in support of the teaching and learning of mathematics and advising the DfES and the LSC on ICT investment requirements for mathematics in schools and colleges (Smith 2004, p158).

Recommendation 6.13

The Inquiry recommends that the [National Centre of Excellence in the Teaching of Mathematics] NCETM should:

...

- Work...to provide a centre for expertise for...commissioning and dissemination of ...materials to enhance the teaching of mathematics through the use of ICT (Smith 2004, p160).

Clearly there is a belief that information and computer technology (ICT) has the potential to make a significant impact on education and it is government policy that ICT should be available for teachers to exploit, and that development should take place in the use of ICT to teach mathematics.

The use of visual representation in teaching is probably as old as teaching. Around 300 BC Plato described how Socrates drew figures in the sand to illustrate the concept of the square root of two (Hamilton and Cairns 1973, p365). In the last decade of the 20th century Arganbright (1993) finds that the

format and the graphic capabilities of a computer spreadsheet make it "an excellent tool for visualizing mathematical concepts". Socrates' use of illustration was to assist the pupil to visualise and put into words the concept of the square root of two. The illustration supported questioning to stimulate mental activity; "This knowledge will not come from teaching but from questioning." (Hamilton *et al.* 1973, p370). Arganbright (1993) advocates the use of spreadsheets as a way of encouraging "new ways of thinking", and of stimulating "intellectual creativity".

Although Piaget (1971, p78-80) cannot be quoted as an advocate of the use of technology, he was certainly open-minded about possible benefits from appropriate use of technology. Acknowledging that every discipline must include a certain amount of facts, he recognised that memorising had a part to play in learning and he entertained the possibility that teaching machines might be able to transmit information more efficiently than other methods. In the 1930s he had two major, and possibly damning, criticisms of teaching machines. The first was that their development was motivated more from commercial than educational needs. The second was that the programmers of the machines merely transposed the contents of textbooks into a mechanised form and he considered that many of the textbooks which programmers could readily transpose were, in any case, of dubious quality. Laurillard (1997) recognises similar limitations in the use of technology later in the 20th century. Referring to her analysis of teaching media she states

...most of them fail to provide feedback on students' description of their conceptualisation of a topic, and also fail to support the reflection they need to do in order to conceptualise and describe the experiences they have had within a learning session (Laurillard 1997, p 215).

Her criticism suggests that the materials under review had been designed from a knowledge-transmission perspective of learning; what Biggs (2003) calls level 1 teaching.

Mayes and de Freitas (2005, p5) call for the role to be played by technology to be defined within the overall educational design process and not judged by separate criteria. This reiterates Laurillard's (1997, p216) view that the success of new technology materials depends upon how they are integrated into courses. It is clearly logical that the choice of a tool or medium must take into account the purpose for which it is being employed.

According to Petty (1998, p316) almost 90% of information we take in is absorbed visually. He recognises many advantages of the overhead projector over the blackboard or whiteboard and lists the main advantages as

- ... make difficult concepts easy to explain
- It saves you a great deal of time in class, enabling you to concentrate on more pressing matters
- You can face the class...
- Complicated diagrams may be drawn to a high standard of accuracy (Petty 1998, p319).

Petty (1998, p324) also describes techniques for overlaying and combining acetate sheets to achieve effective illustrations and includes some well-established principles, such as minimising the number of words on the acetate; highlighting important words and purposeful use of colour.

Electronic data projectors, connected directly to computers, can render overhead projectors and acetate sheets obsolete. Guiding principles for creating and using visual aids, although they may be subjective, are relevant no matter whether the projected image is from an acetate sheet or from an electronic source.

For evaluation of computer-based material Petty includes the following simple common-sense criteria

- Does it do something that needs doing?
- Is the resource interactive? 'Page turners' soon bore students.
- Value for effort. Is it going to take the students so long to learn how to use the material that the educational gains are not worth their effort? (Petty 1998, p337).

Modernising the medium can be justified for reasons which have little impact on pedagogy or on the effectiveness of learning. From a teacher's perspective it may be simpler and more convenient to use electronic projection than to manipulate a number of acetates, especially if a computer is used in the design and creation of the acetates. If the teacher feels more comfortable with the medium then this must have a beneficial effect on the audience; transition between projected images may be quicker, reducing the potential for distraction and making better use of students' attention span, but this does not fundamentally change the pedagogy.

2.5.2 Pedagogy

If ICT is to be more than just an alternative medium then we have to decide on the role of technology within the pedagogy. In a review of current developments in e-learning Mayes and de Freitas (2005) identify three broad,

overlapping perspectives in educational theory; the associative/empiricist perspective (learning as activity); the cognitive perspective (learning as achieving understanding) and the situative perspective (learning as social practice). A precise definition of e-learning is elusive. It encompasses virtually any use of electronic technology for educational purposes. The majority of the developments reviewed fall into the second of these broad perspectives, the cognitive perspective (learning as achieving understanding).

Webb (2005) analyses examples of successful incorporation of ICT into pedagogies for science education. Both Webb (2005) and Heid (2002, p97) cite a wider range of experience as one of the potential benefits from the use of technology. In 2002 Heid had been using computer algebra systems (CAS) for 20 years. As an advocate of their use, she outlines ways in which she has used them based on theories of learning (Heid 2002, 95-108), acknowledging that the potential impact of this technology is dependent on how it is used (Heid 2002, p97). In her concluding remarks she indicates a belief that the use of CAS changes the environment in which mathematics is learned and calls for further research "based in the mathematics classroom" (Heid 2002, p109).

Goos et al (2000, p317) logically reason that it is natural for teachers to use new technologies in ways that are consistent with their preferred teaching methods, but warn that this may constrain a tool to uses which do not exploit its potential. They find that technology can be used to make mathematics meaningful to students but warn that there is not a simple 'cause and effect' relationship in the use of any new technologies, which supports Biggs' concept of constructive alignment: materials and activities have to be matched to the learners' needs.

Kissane (2003, p153 -157) theorises possible stages in the incorporation of technology into practice and suggests that full incorporation is more likely to take years than months. In the initial stage the teacher has to become familiar with the technology. In stages 2 and 3 the teacher progresses from making occasional, particular use to routine use. In the fourth and final stage, use of the technology has an influence on the content of the curriculum. There is correspondence between this four-stage model and the three-stage model suggested by McCormick and Scrimshaw (2001) where initially the teacher uses technology to do more efficiently what the teacher normally does; technology can then be used to extend the range or scope of what the teacher does; and in the final stage the curriculum can be completely transformed by the use of technology.

It cannot be overemphasised that the availability of technology, however intelligent, versatile and amenable it may be, will not by itself have an impact on learning. It is the way in which it is used that can have an impact. Webb (2005, p731) refers to a study that revealed 'misplaced expectation that ICT could work unaided without pedagogical guidance'. Mayes and de Freitas (2005, p15) point to disillusionment with computer-based learning in the last two decades of the 20th century and attribute this to a "discredited idea" that the "vivid and naturalistic representations of knowledge" made available through multimedia would lead to more effective learning.

2.5.3 Summary

The United Kingdom Government is committed to the development of ICT materials and the use of ICT in the teaching of mathematics (Smith 2004,

p158/160). Currently, there is no evidence of widespread use of electronic materials for teaching (BECTa 2004, p3).

While there is criticism of early developments in the use of technology in teaching (Laurillard 1997, p215; Mayes *et al.* 2005, p15), there are studies which report successful use (Kaput 1992; Goos *et al.* 2000; Heid 2002; Kissane 2003; Webb 2005). A common factor in studies which report successful use of technology seems to be that consideration has been given to how a tool can be used within the employed pedagogy.

2.6 Chapter Summary

2.6.1 Documented problems with mathematics education

In 1982 and 2002 the United Kingdom Government commissioned enquiries into the state of mathematics education. Some of the findings of the latter report (Smith 2004) echo those of the former report (Cockcroft 1982). Cockcroft (1982, p243) recognised a shortage of qualified teachers of mathematics. Smith (2004, p151-153) makes recommendations for training of mathematics teachers. A major development during the period between these reports has been the implementation of the National Curriculum (DfEE 1999). Throughout this period researchers (Laurillard 1997; Savage *et al.* 2000; Egerton 2001; Pyle 2001; Kent 2002; White 2002; Hawley 2003; Tomlinson 2004; Tariq 2005) have continued to highlight problems with mathematics education.

2.6.2 Mathematics education

There is a consensus that mathematics should be part of a wider education (Robbins 1963; Piaget 1971; Cockcroft 1982; Pritcher 1985; Dossey 1992; Laurillard 1997; Petty 1998; Nickson 2000; Biggs 2003; Daniel 2003; DfES 2003b; Hawley 2003; Burghes and Hindle 2004; Tomlinson 2004), and that education is concerned with a range of cognitive processes from acquisition of knowledge to analysis and evaluation.

2.6.3 Widening participation

The growth rate of participants in Higher Education increased dramatically after the Robbins (1963) report. In 2002, 43% of 18- to 30- year olds participated in Higher Education. The government's intention is for growth to continue until this figure reaches 50% (DfES 2003a, p57).

2.6.4 Use of Information and Communications Technology (ICT) in education

While there is acknowledgment of potential benefits from the use of ICT in the teaching and learning of mathematics (Smith 2004, p133,134), there is recognition that it will take time for uses of ICT to reach their potential (Kissane 2003, p153 -157). Mayes et al (Mayes *et al.* 2005) maintain that the use of ICT should be defined within the overall educational design process. This view is supported by studies (Kaput 1992; Goos *et al.* 2000; Heid 2002; Kissane 2003; Webb 2005) which report successful use of ICT where consideration has been given to its pedagogic purpose.

Chapter 3: Methodology

3.1 Introduction

The concept of constructive alignment was introduced in Chapter 2.

Constructive alignment is a design for teaching calculated to encourage deep engagement (Biggs 2003, p32).

This study is intended to investigate the question; how can technology be used in the mathematics classroom to facilitate constructive alignment?

The purpose of an educational course is conventionally expressed in terms of learning outcomes. The principle of constructive alignment is that all factors which influence the learning outcomes interact with each other as a system. For the system to function successfully the components have to work in harmony (alignment) with each other. Any contention or conflict (misalignment) between two or more components can lead to failure or degradation of the system. The criterion for success of the system is how well it achieves its purpose. The term 'deep engagement' implies that the purpose of education, or learning outcomes, should be expressed in terms of higher cognitive skills rather than in terms of recall of facts and information.

The principal factors which affect learning outcomes are

- The curriculum taught
- The teaching methods adopted
- The assessment procedures used, and methods of reporting results
- The climate created in interactions between students and teachers

- The institutional climate, the rules and procedures adopted by the institutions. (Biggs 2003, p26)

These factors are encompassed in Figure 3.1. The bidirectional arrows in the figure show three interactions which can be expected to take place in a learning situation.

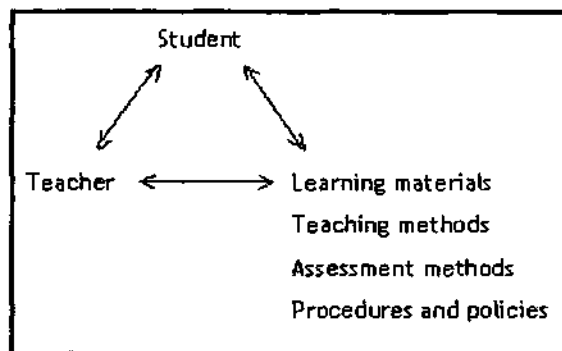


Figure 3.1: Interactions in the learning process

The use and expectation of information and communications technology (ICT) in education is discussed in Chapter 2. The role(s) of ICT within effective pedagogies is/are still evolving. This study examines the use of computer-based presentation materials in the mathematics classroom and identifies benefits and limitations of the resources. In Figure 3.1, presentation materials are included under the general term, learning materials. It can be seen from Figure 3.1 that learning materials can influence the student, both directly and indirectly via the teacher.

3.2 The course which is the subject of the study

This study is based on a 2-week summer school in mathematics.

The broad purpose of the summer school is to prepare students for entry to the Foundation Pathways in Technology (FPT) programme at the University of Plymouth. Successful completion of the one-year (FPT) programme qualifies students for entry to degree courses in mathematics and technology. The FPT programme provides an alternative pathway into Higher Education, for students who do not have the necessary A level qualifications. It focuses on thinking and problem solving with emphasis on understanding mathematical and scientific principles (University of Plymouth 2005).

Successful applicants for the FPT programme are given the opportunity of attending the mathematics summer school. This provides a facility for those who have not been engaged in formal education for some time to refresh their skills. Some applicants for the FPT programme are offered a place on condition of successful completion of the summer school.

The summer school aims to strengthen the students' confidence and their ability in mathematics by refreshing their basic mathematical skills and encouraging and developing their understanding of mathematics. While the role of the tutor may be crucial in resolving uncertainties and misunderstandings, the teaching materials will undoubtedly have an influence on the learning outcomes. It is the influence of the computer based presentation material which is the focus of this study.

3.2.1 Ethos

The ethos of the (FPT) programme is described in the course brochure (University of Plymouth 2005). The University places emphasis on individual potential. This is reflected in the assessment model of the FPT course. The course is assessed on a continuous basis, without any formal end of year examination. Assessment is by regular assignments and in-class tests throughout the year and students are encouraged to monitor their own progress. The emphasis of the course is on understanding mathematical and scientific principles applied to the real world to provide a sound basis for further study. This means that tests and assignments are intended to assess problem-solving skills rather than the ability to memorise large amounts of information.

The two-week summer school is intended to revive and consolidate basic mathematical skills immediately prior to the start of the one-year (FPT) programme. Students' attainment in mathematics prior to joining the course is likely to be grade C GSCE or below, although some may have a higher qualification. Some may not have been engaged in formal education for a period of time. The intention is to create an environment where students feel sufficiently confident to declare any uncertainties or lack of understanding. Resolution of uncertainties builds confidence and building confidence is an aim of the summer school.

3.2.2 Course content, teaching methods and assessment

The topics covered in the two-week summer school are listed in Table 3.1.

Topics covered on summer school
Fractions
Negative numbers
Linear equations
Expanding brackets
Equations from formulae
Forming equations
Rearranging formulae
Indices
Graphs
Trigonometry

Table 3.1: Topics covered on summer school

Cockcroft (1982, p71) identified six elements considered necessary for successful teaching of mathematics to all ages, exposition, discussion, consolidation, problem solving, practical work and investigational work. The teaching method employed on the summer school was essentially traditional; exposition with questions and discussion followed by practice with individual support. The brevity of the summer school excluded practical and investigational work. While Cockcroft (1982, p71) considered these elements necessary, the report was made in the context of the entire mathematics curriculum for secondary education. The emphasis in the summer school was on the development and/or consolidation of skills and confidence in the topic areas listed in Table 3.1.

A booklet of course notes and exercises, with solutions, was provided in advance of the course and students were encouraged to work through the booklet ahead of the tutor if they could.

For exposition, extensive, but not exclusive, use was made of computer-based material projected onto a screen. The topics for which computer-based materials were used are shown in Appendix H. A conventional whiteboard was also used.

Assessment on the course consisted of seven topic tests and a final test covering all topics. Topic tests on Fractions, Solving equations, Transposition of formulae, Indices, Graphs, Equation of a line and Trigonometry were held at the start of the day following completion of the topic, and took approximately 15 minutes. Topic tests were marked and returned to students on the same day as the test. The tutor discussed and corrected incorrect answers with individuals.

The final, overall test was scheduled for the last day of the summer school and an hour was allowed for this. Four students opted to take the final test at the start of the second week of the summer school. The test paper for these four students was equivalent but not identical to the test paper taken by the remainder of the students on the final day. The four students who took the test early had their results the following day. The remainder of the students, who took the test on the final day, had their results on the same day as the test. Students whose acceptance onto the FPT programme depended on their performance on the summer school were expected to score a mean of at least 40% between the topic tests and the final test.

3.3 The computer-based presentation materials

Some of the presentation material comprises fixed examples which can be advanced or retraced in steps. Other material provides a higher degree of interactivity and allows parameters to be changed by the user. All electronic materials used on the course were provided on a compact disk (CD) for each student and access to a computer lab was available during the summer school. A potential benefit of the interactive materials is that when students revise in their own time they are not limited to particular examples covered in the lesson. They can replicate examples presented in class and they can also experiment by using different values of parameters.

3.3.1 A basic presentation

Revision of rules for order of precedence of arithmetic operations

This is a straightforward, brief presentation showing an example of application of the rules. Figures 3.2 (a) to 3.2 (d) show the line-by-line progression of the presentation, which is intended as a reminder of the rules. By asking the group to calculate, mentally, $2 + 3 \times 4$, an indication can be gained of awareness of the rules. The presentation may then be sufficient to consolidate or remind students of the rules. It is constructive to ask students to anticipate the next line before it is shown.

$$(4 + 1) \times 2 - 20 \div (7 - 3) + 4 \times 3 - 8$$

Figure 3.2 (a) Initial screen

$$\begin{array}{l} (4 + 1) \times 2 - 20 \div (7 - 3) + 4 \times 3 - 8 \\ 5 \times 2 - 20 \div 4 + 4 \times 3 - 8 \end{array}$$

Figure 3.2 (b): 2nd screen - Brackets first

$$\begin{array}{l} (4 + 1) \times 2 - 20 \div (7 - 3) + 4 \times 3 - 8 \\ 5 \times 2 - 20 \div 4 + 4 \times 3 - 8 \\ 10 - 5 + 12 - 8 \end{array}$$

Figure 3.2 (c): 3rd screen - Multiplication and division

$$\begin{array}{l} (4 + 1) \times 2 - 20 \div (7 - 3) + 4 \times 3 - 8 \\ 5 \times 2 - 20 \div 4 + 4 \times 3 - 8 \\ 10 - 5 + 12 - 8 = 9 \end{array}$$

Order:

() brackets first

+ x then division & multiplication

+ - then addition & subtraction

◀ ◀ Exit

Figure 3.2 (d): final screen – add and subtract

Figure 3.2: Order of precedence of operations

3.3.2 Illustrated presentations

Introducing the concept of balance to solve linear equations

In Chapter 1 a description was given of how students are asked to solve the simple equation, $x + 2 = 7$ and to explain their method. The scales are used to illustrate a process that can then be used to solve progressively more complicated equations, $2x + 3 = 11$ and $x - 2 = 6$. These are fixed examples: to illustrate solutions of different equations would require the creation of new material. The purpose of the presentation is to illustrate a concept and a logical process. The potential benefit of the electronic slide show is in the graphic illustration of the concept of balance. It is anticipated that students will then be able to apply the principle to solve other similar equations. At this point students can be asked to solve similar equations using paper and pencil.

Logical solution of linear equations: fixed examples

Figure 3.3 shows an example of the presentation material used in the next stage of solving linear equations. The same concept of balance is used but the picture of scales is replaced by textual annotations on the right hand side of the screen. The solution of the equation $5x - 8 = 3x + 4$ is illustrated.

Figure 3.3 (a) shows the initial screen and Figures 3.3 (b) to 3.3 (j) show the successive screens.

A potential benefit of the electronic presentation is the ease with which the presenter can adjust the pace, repeat any step or repeat all of the presentation in response to the reaction of the group. The example and the method are fixed, which can be seen as a benefit or as a limitation. It may be

seen as a benefit if it is considered best to introduce a specific, algorithmic method: e.g. always start with the x - terms. It may, however, be seen as a limitation that the presentation material shows only one possible procedure. An alternative procedure, starting by adding 8 to both sides of the equation, would be just as effective in solving the equation. It is conceivable that an audience may subconsciously assume that the procedure presented is a preferred procedure, or indeed the only procedure. In using any teaching aid the teacher must be aware of its strengths and limitations and use it accordingly. In the summer school the teacher asked the class for an alternative procedure and, with the final slide (Figure 3.3 (j)) still on display, used a separate conventional white board to work through it with input from the class.

<p>Example 1</p> <p>Solve for x.</p> $5x - 8 = 3x + 4$	
---	--

Figure 3.3 (a) Initial screen

$5x - 8 = 3x + 4$		
		subtract $3x$ from both sides

Figure 3.3 (b): decide what to do

$5x - 8 - 3x = 3x + 4 - 3x$	subtract $3x$ from both sides
-----------------------------	-------------------------------

Figure 3.3 (c): amend both sides of equation

$5x - 8 - 3x = 3x + 4 - 3x$	subtract $3x$ from both sides
$2x - 8 = 4$	simplify

Figure 3.3 (d): simplify

$5x - 8 - 3x = 3x + 4 - 3x$	subtract $3x$ from both sides
$2x - 8 = 4$	simplify
	add 8 to both sides

Figure 3.3 (e): decide what to do next

$5x - 8 - 3x = 3x + 4 - 3x$	subtract $3x$ from both sides
$2x - 8 + 8 = 4 + 8$	simplify
	add 8 to both sides

Figure 3.3 (f): amend both sides of equation

$5x - 8 - 3x = 3x + 4 - 3x$	subtract $3x$ from both sides
$2x - 8 + 8 = 4 + 8$	simplify
	add 8 to both sides
$2x = 12$	simplify

Figure 3.3 (g): simplify

$5x - 8 - 3x = 3x + 4 - 3x$	subtract $3x$ from both sides
$2x - 8 + 8 = 4 + 8$	simplify
	add 8 to both sides
$2x = 12$	simplify
	divide both sides by 2

Figure 3.3 (h): decide what to do next

$5x - 8 - 3x = 3x + 4 - 3x$	subtract 3x from both sides
$2x - 8 + 8 = 4 + 8$	simplify add 8 to both sides
$\frac{2x}{2} = \frac{12}{2}$	simplify divide both sides by 2

Figure 3.3 (i): amend both sides of equation


Example 1	
$5x - 8 - 3x = 3x + 4 - 3x$	subtract 3x from both sides
$2x - 8 + 8 = 4 + 8$	simplify add 8 to both sides
$\frac{2x}{2} = \frac{12}{2}$	simplify divide both sides by 2
$x = 6$	simplify
	

Figure 3.3 (j): final screen

Figure 3.3: Solution of an equation

3.3.3 An interactive presentation

Solution of linear equations

This software allows the user to specify a linear equation to be solved.

Alternatively, the software can generate an equation. Figures 3.4 (a) to 3.4 (f) show a possible sequence of events. The equation $5x - 8 = 3x + 4$ has been selected by the user. The user then has to specify an operation and operand and enter them via the computer keyboard. When the user clicks on the 'GO' button the operation is performed on both sides of the equation. The equation

will always balance, but the user must specify appropriate operations in order to find the solution to the equation.

Equations generated by the computer have integer solutions and make use of pseudo random number generation to provide a virtually inexhaustible supply of exercises. Two levels of computer-generated equation are available, one where only one side of the equation contains a variable, and one where the variable occurs on both sides of the equation.

This software can be used to make similar types of presentation to those made using a conventional white board. While the fixed layout may not be what every presenter would choose, there are potential benefits in the ease with which examples can be displayed and in the consistency and clarity of the display. There is an absence of delays between examples while the board is cleaned, when students' attention can be diverted. A teacher-centred or student-centred approach can be employed. The pedagogy is dependent on the teacher.

A potential benefit to students using the software by themselves is that feedback is given and solutions can be obtained by clicking on the 'Show how' button, which will then indicate the next step by automatically entering an appropriate operation and operand and prompting the user to click on the 'Go' button. The user can use the 'Show how' button repeatedly until the equation is solved.

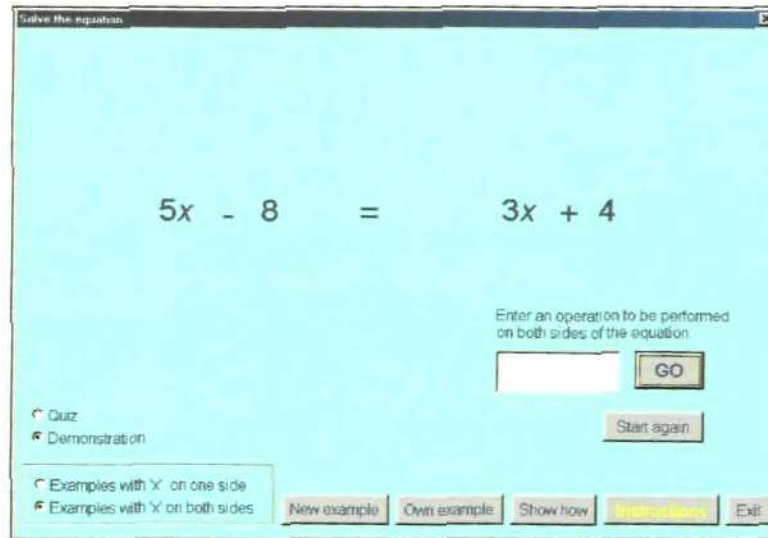


Figure 3.4 (a): An equation to be solved

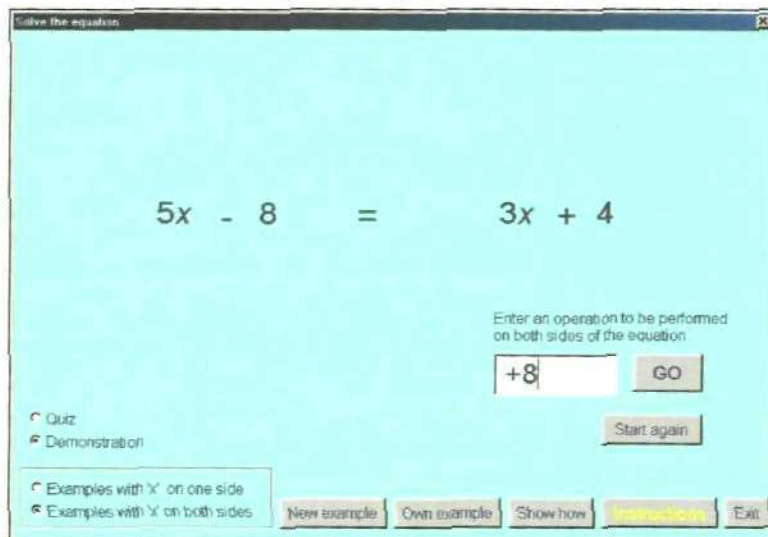


Figure 3.4 (b): User enters "+8"

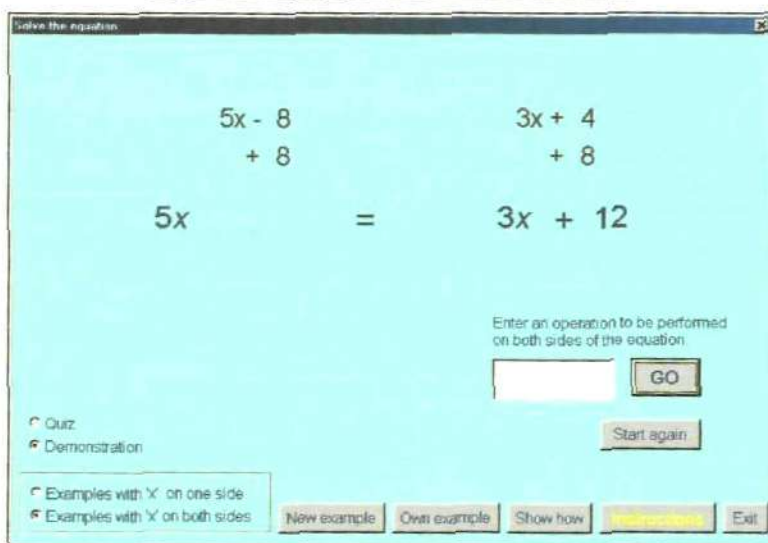


Figure 3.4 (c): User clicks 'GO' Button

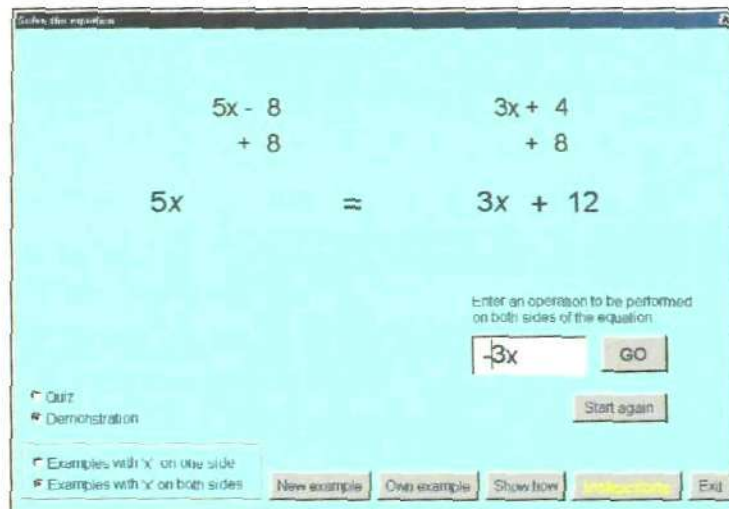


Figure 3.4 (d): User enters "-3x"

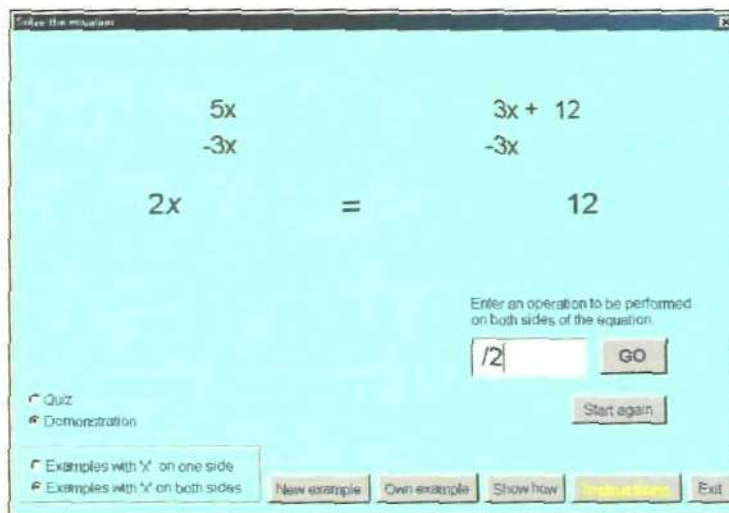


Figure 3.4 (e): User clicks 'GO' Button and then enters "/2"

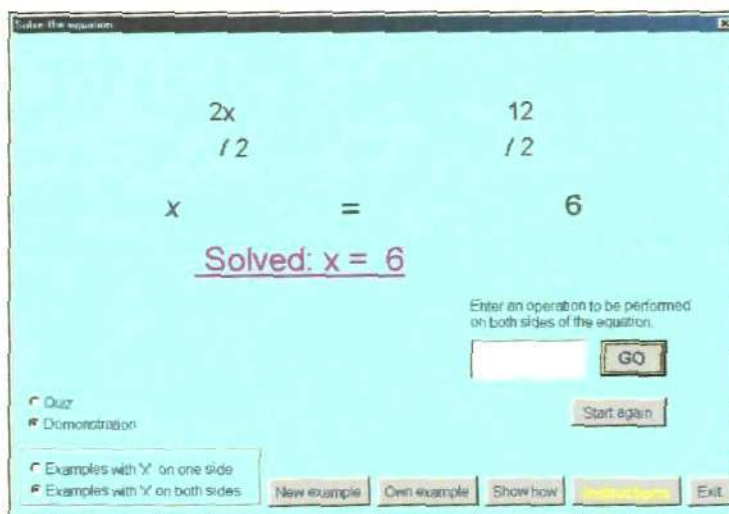


Figure 3.4 (f): equation is solved

Figure 3.4: Interactive solution of an equation

A confusion which can sometimes arise with beginners to algebra, especially with dyslexic students, is the relationship between the coefficient and the variable. Given the equation to solve, $2x = 12$, there is a possibility that they will subtract 2 from the right hand side, remove the '2' from the left hand side and conclude that $x = 10$. A potential benefit to such students is that the software will perform the precise operation specified by the user, to both sides of the equation. Figures 3.5 (a) and (b) show how the software will allow the specified operation to be performed. The student then has to decide on the next operation, which could be to reverse the previous operation by adding 2. If the student is unable to proceed at any stage, they can use the 'Show how' button.

$2x = 12$

Enter an operation to be performed
on both sides of the equation

-2

Figure 3.5 (a): User enters "-2" and clicks 'GO' button

$2x - 2 = 10$

$\begin{matrix} 2x & & 12 \\ -2 & & -2 \end{matrix}$

Figure 3.5 (b): Equation amended as specified by user

Figure 3.5: Interactive solution of an equation – response to input

The presentation material used in this study is listed in Appendix H.

3.4 Data collection

3.4.1 Rationale

The purpose of this research is to discover how technology can be used in the classroom to facilitate constructive alignment. The achievement, or not, of constructive alignment is not absolute: its extent can be qualified. The expected outcome of constructive alignment is that students will engage with the subject using the higher levels of Biggs' (2003, p48, 57) SOLO taxonomy shown in Table 3.2 below. SOLO is an acronym for Structure of Observed Learning Outcomes. The extent to which students engage with the subject, therefore, should indicate the extent of constructive alignment.

'SOLO' Level	Indicative activity
Extended abstract	Theorise; Generalise; Hypothesise; Reflect
Relational	Compare/contrast; Explain causes; Analyse; Relate; Apply
Multistructural	Enumerate; Describe; List; Combine; Do algorithms
Unistructural	Identify; Do simple procedure
Prestructural	Misses the point

Table 3.2: Structure of the Observed Learning Outcomes (SOLO) (adapted from Biggs 2003, p48)

As the levels of the taxonomy are descriptive, any numerical measurement or computation of level would be inappropriate. Therefore, qualitative rather than quantitative methods are appropriate for assessing the extent to which students engage with the subject. Analyses of the data will attempt to identify how the uses of computer-based presentation material assisted or inhibited the engagement of students in the study of mathematics.

3.4.2 Methods

Data have been collected through questionnaires, interviews, enrolment forms and test results.

Details of the data collection methods and procedures had been submitted to and approved by the Faculty of Technology Ethics Committee. The submission to the committee is shown in Appendix A.

At the start of the summer school all 15 students enrolled on the course were invited to take part in the study. The purpose of the study was outlined verbally and in accordance with the Ethical Procedure (Appendix A) written invitations to participate (Appendix B) were given out along with the initial questionnaire, Feelings about mathematics (Appendix D).

These documents were issued on the first morning of the course and students were asked to sign and return a copy of the invitation by the end of the day, if they were willing to participate in the study. By the end of the day, twelve students had completed and returned signed consent forms, agreeing to participate.

3.4.2.1 Initial survey and enrolment data

The focus of this study concerned compatibility between students and learning material. It was therefore necessary to obtain profiles of the students. The initial survey was used to assess students' perceptions of mathematics and motivation. The questionnaire is shown in Appendix D. From these questionnaires and enrolment data a brief profile of each student has been created.

3.4.2.2 Interviews

During the last four days of the summer school interviews were conducted. The purpose of the interviews was to assess students' reactions to the computer-based presentation material which was used on the summer school, and to identify any characteristics of their use that made significant impressions on students.

Interviews can be structured formally or informally. A continuum of structures from "closed quantitative" to "informal conversational" is described by Cohen et al (2001, p271). In a closed quantitative interview, the questions are predetermined and the respondents choose from a selection of predetermined responses. At the other end of the continuum, there is no predetermination of questions or topics in an informal conversational interview.

Because of the elusive nature of the information being sought, a closed quantitative interview structure, with scripted questions and a defined selection of possible responses, was not appropriate. The purpose of the interviews was to ascertain the effect(s) of the use of technology. The topic areas of the course provide a suitable framework on which to base the interview questions.

One aim of the course is to encourage students to communicate any lack of understanding, so that it can be resolved and thus build the students' confidence. It is the role of the teacher to establish a working relationship with students in which there is mutual trust and in which students feel able to confide any difficulties. If this is achieved then loyalty to the teacher might inhibit students in providing feedback, verbal or written, which could be

construed by a third party as criticism of the teacher or the teacher's methods. In an interview tone, body language and timing can reveal whether there is more information to be uncovered behind a simple 'Yes' or 'No' reply (Cohen *et al.* 2001, p282; Silverman 2002, p161-164). If the student considered some aspect to be pleasing, then follow-up questions attempted to identify specific benefits that made it pleasing. Similarly, follow-up questions to a negative response attempted to identify specific factors which made something displeasing for that respondent. Keats (Keats 2000, p4) describes this as probing.

To remind students of the materials that had been used, a prompt sheet was used. This consisted of paper prints of the computer-based presentation material that had been projected in the classroom. The prompt sheet is shown in Appendix F.

3.4.2.3 Concluding survey

At the end of the course a survey was conducted to assess the extent to which constructive alignment had been achieved and what role technology had played in assisting or impeding constructive alignment. The questionnaire is shown in Appendix E.

The design of the questionnaire has attempted to give opportunities and encouragement to the respondents to write freely and provide information about what they think. Even if they do not answer the question, they can provide useful information. Most of the questions include a list of topics to be ticked if appropriate followed by a space for voluntary additional comment.

The space provided for comments is not bounded or outlined, which might imply an expected maximum or minimum length of response.

Questions 4 and 8 appear very similar. Question 4 asks, was there any topic where the presentation was particularly helpful to understanding? Question 8 asks, were there any topics or sessions which were particularly effective for you? The reason for this is to allow for different associations which students may perceive. It is possible that some students may associate an experience with a time, e.g. the session on Monday, while others may associate an experience with an event, e.g. the presentation on fractions. The purpose of the questionnaire is to elicit descriptions of experiences.

3.4.2.4 Test scores

Instrumental teaching can provide students with sufficient procedural skills to enable them to pass conventional written skill-based examinations. Test scores, therefore, are not a reliable indicator of deep learning. While deep learning might or might not improve procedural skills, it is not expected to affect them adversely. If deep learning has any effect on test scores, then it is expected to be a positive effect.

3.5 Chapter Summary

This study focuses on the use of electronic presentation material and how it affects constructive alignment.

Constructive alignment is concerned with compatibility between the student, the teacher, and the electronic presentation material.

A description has been given of the material and how it was used by the teacher in this case study. It is not expected that presentation materials can replace the teacher or that every teacher who might use them would use them in the same way.

An initial survey and biographical data were used to acquire profiles of the students. A course feedback questionnaire and interviews were used to assess the compatibility between the students, the teacher and the electronic presentation material.

Chapter 4: Data

4.1 Introduction

This study is intended to investigate the question; how can technology be used in the mathematics classroom to facilitate constructive alignment?

The concept of constructive alignment requires that the characteristics of students should be taken into account: characteristics of the student, the teacher and the learning environment should work in harmony. The study, therefore, is not intended to identify effects of particular practice or particular use of electronic resources that can be generalised for a large population of students. Neither can this study provide answers to satisfy a wide range of learning situations.

It is intended to assess the influence of the use of computer-based resources with a particular group of students. The findings may be applicable to similar students in similar situations.

The chapter presents all the data collected for the study.

4.2 Biographical data

Details of age and qualifications of the group are shown in Table 4.1. These data come from the course enrolment forms, and contribute to students' profiles.

ID	Dob	Age	Highest relevant qualifications disclosed	Qualification date
1	1957	48	Physics 'O' Level B	1973
2	1975	30	Maths GCSE B	2001
*3	1968	37	Maths CSE 3	1984
4	1967	38	Maths 'O' Level B	1983
5	1977	28	Maths GCSE B	1994
6	1981	24	Maths GCSE C	1998
7	1980	25	Maths GCSE C	1996
*8	1979	26	None disclosed	
*9	1984	21	GNVQ level F	
10	1981	24	Science GCSE C	1998
11	1961	44	Maths GCSE C; HNC (Engineering)	1978 1998
12	1980	25	GCSE	
*13	1982	23	Maths GCSE D	1998
*14	1987	18	None disclosed	
15	1986	19	Psychology AS Level ICT AVCE B	2005

Table 4.1: Biographical data

Notes: * Indicates students who depended on passing the summer school to gain entry to the Foundation Pathways in Technology (FPT) Programme.

4.3 Data from initial survey

Twelve students consented to completion of the questionnaire (Appendix D).

Their responses to the eleven questions are shown in Tables 4.2 and 4.3.

The data from this survey was used to construct profiles of the students.

Questions 1 to 4 of the questionnaire ask for information about students' experiences of mathematics. Questions 5 to 9 ask for information on their feelings about mathematics. Question 10 asks for indication of which university school students intend to enter. Responses to questions 1 to 10 are shown in Table 4.2.

Questions 11 asks what students expect to gain from the summer school. The written responses of the students are shown in Table 4.3.

Previous experiences of mathematics														
		ID number	1	2	3	4	5	6	7	8	9	10	11	12
Q1	Position in class	Top	1	1		1		1		1			1	
		Middle					1		1		1	1		1
		Bottom			1									
Q2	Enjoyed	Mostly	1	1		1	1			1		1	1	
		Sometimes						1	1		1			
		Rarely			1									1
Q3	Liked solving problems	Usually	1			1	1	1		1		1		
		Didn't mind		1	1				1		1		1	1
		Not usually												
Q4	Liked specific questions	Usually	1	1				1	1	1				
		Didn't mind			1	1	1				1	1	1	1
		Not usually												
Feelings about mathematics														
		ID number	1	2	3	4	5	6	7	8	9	10	11	12
Q5	Don't need to understand	Agree				1			1	1	1		1	
		Not sure												
		Disagree	1	1	1		1	1				1		1
Q6	Need a good memory	Agree	1			1		1		1			1	1
		Not sure					1		1					
		Disagree		1	1						1	1		
Q7	Need a good teacher	Agree			1	1	1	1	1	1		1	1	1
		Not sure	1								1			
		Disagree		1										
Q8	Experience which made you like	Yes			1	1					1	1	1	
		No	1	1			1	1	1	1				1
Q9	Experience which made you dislike	Yes							1			1	1	
		No	1	1	1	1	1	1		1	1			1
Intended progression														
		ID number	1	2	3	4	5	6	7	8	9	10	11	12
Q10	Which university school?	Computing							1					
		Maths & stats		1		1	1			1			1	
		Engineering	1		1			1			1	1		1
		Don't know												

Table 4.2: Student profiles

Question 11 asks, "What do you expect to gain from this summer school?"

Responses are shown in Table 4.3. Null responses are not shown.

ID	Answer to question 11
1	I feel a bit rusty about maths, having not studied it for a long time. I hope this will give me more confidence.
2	Refresh my knowledge and maybe learn a bit more.
3	Main objective - entry into foundation year. Also a much better understanding for mathematics & to overcome previous fears of tackling equations.
4	To brush up on my basic maths and get my brain into gear for the foundation Pathways. Also to get used to the daily routine.
5	A build up to the foundation year.
6	To leave the course refreshed to a standard that I can continue onto the Foundation Course
7	Brush up maths skills.
8	A place on the course and experience of what the course will be like.
11	Brush up on principles

Table 4.3: Responses to question 11

4.4 Data from feedback questionnaire

The purpose of this end-of-summer-school questionnaire (Appendix E) was to gather evidence of constructive alignment and of the influence of the use of computer-based presentation material.

The 19 questions were intended to provide opportunities for students to describe their reactions to the summer school. Some questions asked specifically about the use of computer-based presentation material. Other questions asked about aspects of the course that might have been affected by the use of computer-based presentation material. It was anticipated that respondents would not respond in full to every question.

Questions 1 to 4 were about the level of difficulty of the summer school.

Questions 5 to 6 were about the content of the summer school.

Questions 7 to 14 were about the delivery methods used on the summer school.

Questions 15 to 18 were about the assessment methods used on the summer school.

Question 19 asked what benefits had been gained from the summer school.

Question 1: This question asks, "Was there any topic or part of the course which you found particularly difficult?"

The responses are shown in Table 4.4. Respondent identifications, ID 1 to 15, are shown on the top row. The second row shows that 6 respondents (IDs 5, 6, 9, 13, 14 and 15) found Fractions particularly difficult.

	ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Count
Fractions						1	1			1				1	1	1	6
Negative numbers															1		1
Expanding brackets																1	1
Linear equations																1	1
Equations from formulae																1	1
Forming equations		1										1				1	3
Rearranging formulae															1	1	2
Indices		1		1		1				1	1					1	6
Graphs				1						1							2
Trigonometry																	0

Table 4.4: Topics of particular difficulty

The second part of the question asks, "What would have made it easier? How could you have been helped?"

Responses are shown in Table 4.5. Respondent identifications are shown in the left hand column. Null responses have been omitted.

ID	
1	I found it more difficult to recall information in these areas, but the tutor was helpful.
3	Myself - more study + taking more time over reading questions & examples.
5	$(x^{-\frac{1}{2}} = \frac{1}{\sqrt{x}})$ More information relating to above question.
6	Tutorials given very adequate.
11	I am not sure. I've always had difficulty in extracting the information required from word type problems or modelling but I'm sure its down to lack of practice. I am increasingly coming across these types of problems at the moment and perhaps a little more time in this area would be useful.
13	The amount of help available was excellent, and it was only the fact that it has been so long since I've done fractions that it was only a case of getting my brain in gear.
14	More time to practice and maybe doing more examples through as a class?
15	More questions in the book would have helped. Also more explanations in different contexts would have helped a great deal. I found the book contained a few mistakes which was very off putting and confusing.

Table 4.5: What would have made it easier?

Question 2: This question asks, "Was there anything that you think you could have understood better had it been presented differently?"

Topics identified by respondents are shown in Table 4.6. Respondent identifications, ID 1 to 15, are shown on the top row. The second row shows that one respondent (ID 15) thought that Fractions could have been understood better had it been presented differently.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fractions															1
Negative numbers															
Expanding brackets															1
Linear equations															1
Equations from formulae															1
Forming equations					1										1
Rearranging formulae															1
Indices					1										1
Graphs															
Trigonometry										1					

Table 4.6: Topic identified in question 2

The question also asks, "What differences would you have preferred?"

Responses are shown in Table 4.7. Respondent identifications are shown in the left hand column. Null responses have been omitted.

ID	
5	More info
10	I found the trigonometry quite slow and would have preferred to learn about tan cos and sin together.
11	All topics were explained and presented well and I was happy with the understanding of the topics.
14	More examples done with the class as a whole as I found this topic a little difficult and going through it in more detail would have helped. Also the book had a few different types of formulas than those looked at on the board. which I found difficult because I was unsure of how to approach them.
15	More examples and more ways of working them out.

Table 4.7: Suggested improvements

Question 3: This question asks, "Were there any topics which you found easy?" For topics identified by the respondent, supplementary questions ask, "Had you done this before? For you, could the time spent on this have been reduced?"

Responses are shown in Table 4.8. Respondent identifications, ID 1 to 15, are shown on the top row. The second row shows that three respondents (IDs 1, 2 and 11) found the topic, Fractions, easy.

Two respondents added additional comments. These are shown in Table 4.9.

1=yes: topic found to be easy y=yes n=no

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Count
Fractions	1	1									1					3
Done before?	y	y			y	n	y		n		y			y	y	
Reduce time?		y			n		n		n		y			n	n	
Negative numbers					1		1				1				1	4
Done before?					y	y	y		y		y			y	y	
Reduce time?					y		n		n		n			n	n	
Expanding brackets					1		1									2
Done before?					y	y	y		n		y			y	n	
Reduce time?					n		n		n		n			n	n	
Linear equations		1			1											2
Done before?		y			y	y	y		y		y			n	n	
Reduce time?		y			y		n		n		n			n	n	
Equations from formulae			1		1		1		1		1			1		6
Done before?			n		y	y	y		y		y			y	n	
Reduce time?			n		y		n		n		n			n	n	
Forming equations					1		1		1					1		4
Done before?					y	y	y		y					y	n	
Reduce time?					n		n		n		n			n	n	
Rearranging formulae			1		1		1		1		1					5
Done before?			n		y	y	y		y		y			y	n	
Reduce time?			n		n		n		n		n			n	n	
Indices		1			1						1		1			4
Done before?		y			y	n	y		n		y		y	y	n	
Reduce time?		n			n		n		n		n		n	n	n	
Graphs					1		1				1				1	5
Done before?					y	y	y		y		y			y	y	
Reduce time?					y		n		n		y			y	n	
Trigonometry		1			1	1	1		1		1		1	1	1	9
Done before?		y			y		y		y		y		y	y	n	
Reduce time?		y			y	y	n		n		y		n	n	n	

Table 4.8: Topics found to be easy

3	I enjoy time being spent on subjects that I do understand as well as subjects I don't.
10	The graphs I found to be very easy.

Table 4.9: Comments relating to question 3

Note: Respondent 10 submitted his responses on a separately typed sheet, not on the standard form.

Question 4: This question asks, "Was there any topic where the presentation was particularly helpful to understanding?"

Responses are shown in Table 4.10. Respondent identifications, ID 1 to 15, are shown on the top row. The second row shows 5 respondents, (IDs 1, 3, 5, 8 and 14) considered that the presentation of Fractions was particularly helpful to understanding.

	ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Count
Fractions		1		1		1			1						1		5
Negative numbers						1			1	1	1			1			5
Expanding brackets						1			1	1		1		1			5
Linear equations						1			1	1		1		1			5
Equations from formulae		1				1			1	1				1			5
Forming equations						1			1	1				1			4
Rearranging formulae		1				1	1		1	1		1		1			7
Indices						1			1	1		1					4
Graphs				1					1	1		1		1	1		6
Trigonometry		1		1					1						1	1	5

Table 4.10: Topics where presentation was considered particularly helpful

A supplementary part to question 4 asks, "What aspect made it helpful?"

Responses are shown in Table 4.11. The right hand columns show that five of the aspects can be categorised as relating to the tutor; six can be categorised

as relating to resources; and three identified a particular characteristic. Null responses are not shown.

ID		Tutor related	ICT resources	Step-by-step/ simplification
1	...tutors demonstration on interactive board	1	1	
3	I found the revision pack book very clear. Also the on screen projector was useful especially for trigonometry.		1	
5	Good communication with the tutor.	1		
6	The explanation on how to do it one step at a time	1		1
8	with a teacher explaining and helping you, it makes things simpler.	1		
9	All the topics was [sic] explained properly and taught well. The topic Fractions I feel was rushed a bit but other wise the computer & the projector made it a lot easier to understand what the teacher was trying to explain.	1	1	
10	I liked the kangaroo it really helped me get my head around negative multiplication.		1	
11	Work on the Graphics calculator was very useful. Perhaps a little more time explaining the functions would be appreciated as the T84 is used extensively on the pathways course.			
13	The use of IT was particularly helpful as it easily simplified each process. I fully understood negative numbers thanks to Mr Kangaroo!		1	1
14	Using the board and the CDs on the computers helped to go through everything step by step which helped increase my confidence in the topics by giving an example then using interactive tests.		1	1
Totals		5	6	3

Table 4.11: Aspects which made presentations helpful

Question 5: This question asks, "Do you think any of the topic areas should have been omitted?"

Responses are shown in Table 4.12. Graphs is the only topic selected by any respondent.

	ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fractions																
Negative numbers																
Expanding brackets																
Linear equations																
Equations from formulae																
Forming equations																
Rearranging formulae																
Indices																
Graphs								1							1	
Trigonometry																

Table 4.12: Topic which respondents think should have been omitted.

A supplementary part to question 5 requests, "If possible please indicate why you think the topic area(s) should have been omitted."

Responses are shown in Table 4.13

ID	
7	The very basic stuff on graphs was too easy for me.
10	Content was great for the test.
14	Mainly because most people knew about graphs and what isn't known can be taught pretty quickly.

Table 4.13: Reasons why topic should be omitted

Question 6: This question asks, "Were there any topic areas, which were not included, which you think should have been included?"

If yes, please list any topics"

Responses are shown in Table 4.14. Null responses are not shown.

ID	
1	$\sin \theta$ and $\cos \theta$ to find triangles without right angles. Vectors
2	Simultaneous equations. Surds
5	More application to real life situations.
6	Long Multiplication and Long Division. I myself do not have a problem with this but I have heard people within the group say that they cannot do either
13	The course is structured very well and I think that if time allowed then it [would] have been good to go through simultaneous equations.

Table 4.14: Topics which respondents consider should be included

A supplementary part to question 6 requests, "If possible, briefly indicate why you think they should have been included."

Only one student responded. The response is shown in Table 4.15.

ID	
11	Logarithms (natural and base 10) and exponential functions to a greater depth would have been useful. I never really understood the process behind them at school and now find how increasingly important they are.

Table 4.15:Reasons why topic(s) should have been included

Question 7: This question asks, "Were there any topics or sessions which you consider could have been presented better? If yes, please indicate which topic(s) in the Table below."

Responses are shown in Table 4.16. The second row shows that four respondents (IDs 5, 6, 9 and 15) thought that Fractions could have been better presented.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Count
Fractions					1	1			1						1	4
Negative numbers																0
Expanding brackets														1		1
Linear equations																0
Equations from formulae																0
Forming equations														1		1
Rearranging formulae																0
Indices					1					1						2
Graphs																0
Trigonometry																0

Table 4.16: Topics which could have been better presented

A supplementary part to question 7 requests, "If possible please indicate why."

Responses are shown in Table 4.17. Null responses are not shown.

ID	
5	I still don't understand $x^{-\frac{1}{2}} = \frac{1}{\sqrt{x}}$ Fractions & roots could be better connected to indices.
6	I think long multiplication and long division should be included or run adjacent to this module. As sometimes the numbers are large and the ability to solve it without a calculator increases your understanding.
9	Like I said before [I] felt that fractions was slightly rushed. Using the projector & certain software to show us how fractions work, but was showing to[o] much at any given time.
10	I found the indices lesson difficult.
14	I think because it took me a while to get my head around what I had to do and what the question was asking me. Although I thought that it was presented ok but I felt that I just needed to practice them a bit more.
15	More time should have been spent on fractions. Also more help should be given on the CD. More examples would help and also a few ways of getting an answer would help.

Table 4.17: Reasons why presentation could have been better

Question 8: This question asks, "Were there any topics or sessions which were particularly effective for you?"

Responses are shown in Table 4.18. Respondent identifications, ID 1 to 15, are shown on the top row. The second row shows 4 respondents, (IDs 3, 9, 10 and 13) considered the topic, Fractions to be particularly effective.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Count
Fractions			1						1	1			1			4
Negative numbers									1				1			2
Expanding brackets			1						1				1			3
Linear equations					1				1				1			3
Equations from formulae					1				1		1		1	1		5
Forming equations					1				1				1			3
Rearranging formulae					1	1			1		1		1			5
Indices			1						1				1			3
Graphs		1	1						1		1		1	1	1	7
Trigonometry	1		1						1				1	1		5

Table 4.18: Topics considered to be particularly effective

A supplementary part to question 8 requests, "If possible please indicate what made them particularly effective."

Responses are shown in Table 4.19. Null responses are not shown.

ID	
1	trig well explained
2	Because I haven't covered this since school
3	I found these topic areas effective as by the end of the course I had a much better understanding
5	The topics are presented in a way which relates to each other.
6	Has been my most inconsistent area of maths.
9	All topics were effective I took time at home to go through the CD, which explained any problems I had encountered easily and effectively.
10	The fractions lesson was very effective.
11	The subjects ticked were areas that I have not touched since the HNC mathematics module and found these very useful on brushing up on my knowledge
14	The way they were explained in both the book and its examples, and in the classroom.

Table 4.19: Reasons why topics were considered particularly effective

Question 9: This question asks, "Did you find the use of computer-based material for presentation by the teacher helpful?" For each of the ten topics respondents were asked to indicate 'Yes', 'No' or 'Don't know/not applicable'.

Table 4.20 shows 'Yes' responses. Table 4.21 shows 'No' responses. Table 4.22 shows 'Don't know/not applicable' responses.

	ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fractions			1					1	1	1		1		1	1	
Negative numbers								1	1	1		1		1		
Expanding brackets	1							1	1	1		1		1		
Linear equations	1				1			1	1	1		1		1		1
Equations from formulae	1				1			1	1	1		1		1	1	1
Forming equations	1				1			1	1	1		1		1	1	1
Rearranging formulae	1				1	1		1	1	1		1		1	1	
Indices			1		1			1	1	1		1		1	1	
Graphs	1		1					1	1	1		1		1	1	
Trigonometry	1		1						1	1		1		1		

Table 4.20: 'Yes' response to question 9

	ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fractions					1											1
Negative numbers					1										1	1
Expanding brackets					1										1	1
Linear equations															1	
Equations from formulae																
Forming equations																
Rearranging formulae																
Indices																
Graphs					1											
Trigonometry					1											

Table 4.21: 'No' response to question 9

	ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fractions	1	1														
Negative numbers	1	1														
Expanding brackets		1														
Linear equations		1														
Equations from formulae		1														
Forming equations		1														
Rearranging formulae		1														1
Indices	1	1														1
Graphs		1														1
Trigonometry		1						1							1	1

Table 4.22: 'Don't know/not applicable' response to question 9

A supplement to question 9 requests, "Please add any comment which you think appropriate."

Responses are shown in Table 4.23. Null responses are not shown.

ID	
2	...don't think it would have made much/any difference.
3	As I can see the benefits of the use of computer for demonstrating maths I would hate to see the blackboards disappear from the classroom as it adds to the atmosphere. I think a mixture of computer & blackboard for teaching would achieve best results.
5	Computers are useful, but could be made more useful.
6	Also the software on logs was very helpful.
7	Presentation on trig could have included intro on rearranging the equation and remembering the SOHCAHTOA nemonic [sic]. Although having said this the test was only on Tan.
8	It showed the correct step by step process to getting the answer. It was very clear which helped my understanding of each topic
9	Very effective software, easy to use & understand & I think this should be used in other classes as well.
10	For presentation the computer based material was good but a remote mouse may have been useful.
13	Awesome, a great way to fully understand a topic. Good use of the kangaroo!

Table 4.23: Helpfulness of computer-based presentation material

Question 10: This question asks, "Did you find computer based material used by you helpful?"

For each of the ten topics respondents were asked to indicate 'Yes', 'No' or 'Don't know/not applicable'. Responses are shown in Tables 4.24 to 4.26.

Table 4.24 shows 'Yes' responses. Table 4.25 shows 'No' responses. Table 4.26 shows 'Don't know/not applicable ' responses.

	ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fractions				1				1	1	1		1			1	
Negative numbers								1	1	1		1			1	
Expanding brackets				1				1	1	1		1			1	
Linear equations								1	1	1		1				1
Equations from formulae								1	1	1		1			1	1
Forming equations				1				1	1	1		1				1
Rearranging formulae				1				1	1	1		1			1	
Indices			1	1		1		1	1	1		1			1	
Graphs				1				1	1	1		1				
Trigonometry				1					1	1		1				

Table 4.24: 'Yes' response to question 10

	ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fractions																1
Negative numbers				1												1
Expanding brackets																1
Linear equations																
Equations from formulae				1												
Forming equations																
Rearranging formulae																
Indices																
Graphs																
Trigonometry																

Table 4.25: 'No' response to question 10

	ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fractions			1													
Negative numbers			1												1	
Expanding brackets			1													
Linear equations			1	1											1	
Equations from formulae			1													
Forming equations			1												1	
Rearranging formulae			1													1
Indices			1													1
Graphs			1												1	1
Trigonometry			1					1							1	1

Table 4.26: 'Don't know/not applicable' response to question 10

A supplementary part to question 10 requests, "Please add any comment which you think appropriate."

Responses are shown in Table 4.27. Null responses are not shown.

ID	
1	Material was helpful but I lacked confidence at first.
6	See previous question
7	See over comment on trig
8	I like the tests, because you can practise as much as you want.
10	Computer based learning material did not help me very much.

Table 4.27: Helpfulness of computer-based material used by respondent

Question 11: This question asks, "How much time did the teacher spend speaking/explaining?"

Respondents are asked to select one of five descriptors, listed in the left hand column of Table 4.28, which collates the responses.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Far too much															
A little too much		1													
About right	1		1		1	1	1	1	1		1		1	1	
Not enough															1
Not nearly enough															

Table 4.28: Time spent by teacher speaking/explaining

A supplementary part to question 11 requests, "Please add comment if appropriate."

Only one respondent added a comment, which is shown in Table 4.29

ID 10	Teacher spent approx half lesson time speaking and explaining.
-------	--

Table 4.29: Comment relating to question 11

Question 12: This question asks, "How much time did you have to reflect on the subject and practice by doing examples and exercises?"

Respondents are asked to select one of five descriptors, listed in the left hand column of Table 4.30, which collates the responses.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Far too much															
A little too much											1				
About right	1	1	1			1	1	1					1	1	
Not enough					1				1						1
Not nearly enough															

Table 4.30: Amount of time for students to work by themselves

A supplementary part to question 12 requests, "Please add comment if appropriate."

Only one respondent added a comment, which is shown in Table 4.31

ID 10	About half lesson time spent completing exercises.
-------	--

Table 4.31: Comment relating to question 12

Question 13: This question asks, "How was the balance between presentation/talk by the teacher and time to do examples and exercises?"

Respondents are asked to select one of three descriptors, listed in the left hand column of Table 4.32, which collates the responses.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Too much teacher presentation		1													
About right	1		1		1	1	1	1	1		1		1	1	1
Too much time on exercises.															

Table 4.32: Balance between teacher talking and students working

A supplementary part to question 13 requests, "Please add comment if appropriate."

Only one respondent added a comment, which is shown in Table 4.33

ID 13	Tutor was very good at explaining problems and always had time for people struggling
-------	--

Table 4.33: Comment relating to question 13

Question 14: This question asks, "How much individual support did **you** get?"

Respondents are asked to select one of three descriptors, listed in the left hand column of Table 4.34, which collates the responses.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Too much															1
About right	1	1	1		1	1	1	1	1		1		1	1	
Not enough.															

Table 4.34: Amount of individual support

A supplementary part to question 14 requests, "Please add comment if appropriate."

Responses are shown in Table 4.35.

ID	
14	Individual support was excellent with the teacher taking a pro-active role and asking each student regularly if they needed any help.
15	I think this was very helpful

Table 4.35: Comments relating to question 14

Question 15: This question asks, "Did the assessment reflect the content of the course? Please tick 'Yes' or 'No'."

Responses are shown in Table 4.36.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Yes		1	1			1	1	1	1	1	1		1	1	
No															

Table 4.36: Did the assessment reflect the content of the course?

Question 16: This question asks, "Did the assessment reflect the level of the course? Please tick 'Yes' or 'No'."

Responses are shown in Table 4.37.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Yes		1	1			1	1	1	1		1		1	1	
No										1					

Table 4.37: Did the assessment reflect the level of the course?

Question 17: This question asks, "Do you think that the type of assessments were appropriate? Please tick 'Yes' or 'No'."

Responses are shown in Table 4.38.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Yes		1	1			1	1	1	1		1		1	1	
No															

Table 4.38: Is the type of assessment appropriate?

Question 18: This question asks, "Please indicate any aspect of the assessment which you think could be improved or which you think was not entirely appropriate."

Two students responded. The responses are shown in Table 4.39.

ID 11	The ongoing assessments were a very good indicator on weak areas and highlighted areas of concern.
ID 8	I think some people slowed me and other people down. We wanted to go on to new things, but we had to wait for others. I am not being selfish, but I wanted to learn and excel more than I was allowed.

Table 4.39: Aspects of assessment

Question 19: This question asks, "What benefit do you think you have gained from this course?" Responses are shown in Table 4.40. Null responses are not shown.

ID	
1	It gave me a chance to update my study skills & gave me confidence to begin the foundation course.
2	Brushing up on some old skills and adding confidence. (very useful)
3	My confidence levels of tackling mathematical problems has risen 100%. The benefits will become clear as I progress to the foundation year.
5	I have revised what I learned at G.C.S.E. and built on it.
6	The course has given me a great confidence boost for the level of maths to start the foundation year. It has also made me realise what a friendly place the University is.
7	When I started I thought my maths was poor, but now I know I was just out of practice.
8	Exercised my brain, so that I am ready for the foundation year. (Q18. I think some people slowed me and other people down. We wanted to go on to new things, but we had to wait for others. I am not being selfish, but I wanted to learn and excel more than I was allowed.)
9	My mathematics skills have been reborn & touched up. I have a good understanding with most of the topics we covered. & feel comfortable in a mathematics situation.
10	The course helped ready me for Lectures and Uni life. It made the start of the foundation year a lot gentler and I would recommend it to all mature students regardless of their previous achievements.
11	It has help me a great deal over the first month of the pathways course and I think that reflects on comments from other students who say that they wished they had attended and feel that we've had a head start on the maths module. I just wish there had been a summer school for computers!
13	The maths summer school is an awesome course to do prior to the Foundation Pathway. Being a mature student it has been good to get my brain back in gear.
14	Lots more confidence with maths. Before I came on to the course I truly believed I couldn't do maths at all but Im amazed at how much I seem to have taken in in such a short space of time. It has changed my attitude to maths completely.
15	I think I have gained a higher understanding of maths which I greatly need.

Table 4.40: Benefits from course

4.5 Scores for tests

Table 4.41 shows the final scores for students on the summer school.

ID	Aggregate of topic tests (%)	End-of-summer-school test (%)	Overall score (mean)
1	83.6	100.0	92%
2	90.2	92.5	91%
*3	91.7	100.0	96%
4	94.3	Note 1	
5	69.0	Note 1	
6	95.2	100.0	98%
7	58.1	77.5	68%
*8	96.0	92.5	94%
*9	65.2	92.5	79%
10	83.6	100.0	92%
11	80.7	97.5	89%
12	10.2	Note 2	
*13	77.9	100.0	89%
*14	47.4	67.5	57%
15	46.7	47.5	47%

Table 4.41: Final scores

- Notes:**
- * Students who depended on passing the summer school to gain entry to the Foundation Pathways in Technology (FPT) Programme.
 - 1. Personal circumstances prevented attendance. Unconditional place offered on FPT Programme.
 - 2. Left summer school on 3rd day for personal reasons.

4.6 Initial appraisal of data

From an initial reading of the data the students on the summer school appear to have had quite different backgrounds. Figure 4.1 shows the age profile of the group with a range from 18 to 48 and a median age of 25.

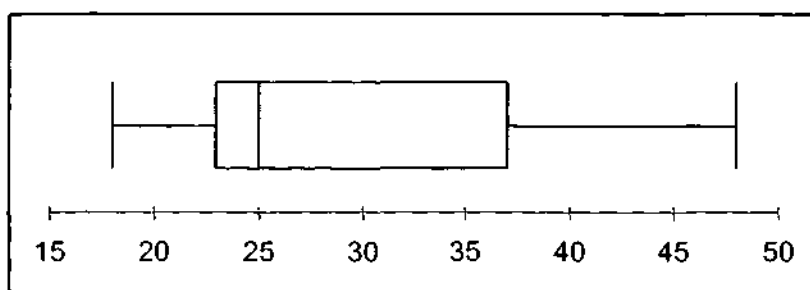


Figure 4.1: Age profile of students on summer school

The qualification profile, shown in Figure 4.2, is similarly diverse; 7 students have disclosed no formal qualification in mathematics; 6 students have a grade C GCSE or better.

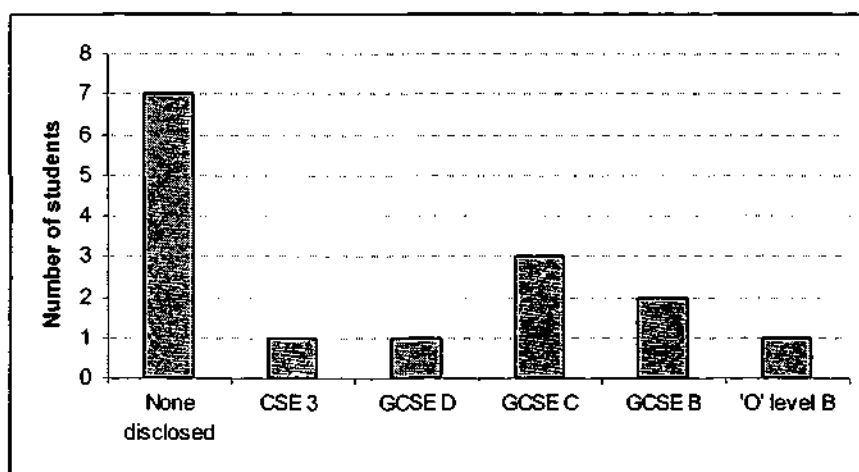


Figure 4.2: Mathematics qualifications of students on summer school

The initial survey indicates a consensus in the belief that success in mathematics is dependent on having a good teacher and, with the possible exception of one respondent, seems to indicate that the group has had mainly positive experiences of mathematics at school. It should be reiterated, however, that three of the 15 students declined to take part in the initial survey. It is perhaps significant that two of these students (ID 14 and 15) are the youngest in the group and neither has disclosed any formal mathematics qualification.

The feedback survey indicates a high level of satisfaction with the summer school. Benefits from the use of computer-based presentation materials have been acknowledged and no one has expressed disapproval of their use.

4.7 Comparison of expectation and achievement

Question 11 of the initial survey asks what the student expected to achieve from the course. This is compared in Table 4.42 with responses to question 19 of the feedback questionnaire, which asks what has been gained from the course, and with responses given in interviews.

Table 4.42: Comparison of expectation and achievement

	Start: What do you expect to gain from this summer school?	Finish: What benefit do you think you have gained from this course?	Interview Transcript is given in Appendix G
1	I feel a bit rusty about maths, having not studied it for a long time. I hope this will give me more confidence.	It gave me a chance to update my study skills & gave me confidence to begin the foundation course.	(Lines 46 - 55): Tutor: Overall on the course what benefit, if any, do you think you've got from the two weeks? Student: I've certainly recalled... I've studied all this... It's just really...refreshed everything in my mind...I'm very confident, much more confident now... Tutor: You said on your initial survey you wanted to brush up on your maths. Did you feel you've done that? Student: Certainly yeh, definitely. Tutor: Do you feel more confident at maths than you did before? Student: Yeh

	Start: What do you expect to gain from this summer school?	Finish: What benefit do you think you have gained from this course?	Interview Transcript is given in Appendix G
2	Refresh my knowledge and maybe learn a bit more.	Brushing up on some old skills and adding confidence. (very useful)	<p>(Lines 135 - 145):</p> <p>Tutor: You said on your initial questionnaire, what you expected to gain from the course was, "to refresh my knowledge and maybe learn a bit more?" Do you feel that you've actually managed to do that?</p> <p>Student: Yes, definitely. I think I would have sat the exam paper – before I did these two weeks - and probably got - I don't know - 75% ish anyway, but I've come in and I've got 92% - I mean a couple of mistakes I could have - I should have got 100 but - It definitely refreshed me and it helped me bring back some of the skills that I have used before and I have learnt a little bit more as well. We covered a bit on logarithms. It's accomplished what I hoped it would.</p>
3	Main objective - entry into foundation year. Also a much better understanding for mathematics & to overcome previous fears of tackling equations.	My confidence levels of tackling mathematical problems has risen 100%. The benefits will become clear as I progress to the foundation year.	<p>(Lines 249 - 257):</p> <p>Tutor: On your initial survey you said what you hoped to gain from the course was a better understanding for mathematics and to overcome some previous fears in tackling equations. Do you think you have managed to achieve that? Or, do you think we have managed to achieve that?</p> <p>Student: Absolutely, absolutely. As I say, I came here with nothing, and since 1984 – was the last time I did any maths at school and I didn't do very well then either, - so basically, everything that I've learned about maths I've learnt in this two weeks.</p>

	Start: What do you expect to gain from this summer school?	Finish: What benefit do you think you have gained from this course?	Interview Transcript is given in Appendix G
4	To brush up on my basic maths and get my brain into gear for the foundation Pathways. Also to get used to the daily routine.		(Lines 322 - 325): Tutor: I think you said on your initial questionnaire, you wanted to brush up on your basic maths and get your brain into gear. Do you feel that you have done that? Student: Yes, definitely, without a doubt. Definitely, without a doubt
5	A build up to the foundation year.	I have revised what I learned at G.C.S.E. and built on it.	
6	To leave the course refreshed to a standard that I can continue onto the Foundation Course	The course has given me a great confidence boost for the level of maths to start the foundation year. It has also made me realise what a friendly place the University is.	(Lines 405 - 411): Tutor: Do you think you've got what you wanted from it? Student: Well, when I accepted coming onto the course, I thought - my main interest was what the level was going to be, required to start the foundation year on. I think without a doubt it's given me a confidence boost, 'cause I now know what sort of level I'm expected to be at for when I go onto the Foundation Year now instead of going in completely blind.
7	Brush up maths skills.	When I started I thought my maths was poor, but now I know I was just out of practice.	(Lines 468 - 471): Student: I benefited in that I came onto this course thinking that I needed to do it because I thought my maths skills were poor which was really a reflection of the fact that I hadn't used them for so long and it was just rusty.

	Start: What do you expect to gain from this summer school?	Finish: What benefit do you think you have gained from this course?	Interview Transcript is given in Appendix G
8	A place on the course and experience of what the course will be like.	Exercised my brain, so that I am ready for the foundation year. (Q18. I think some people slowed me and other people down. We wanted to go on to new things, but we had to wait for others. I am not being selfish, but I wanted to learn and excel more than I was allowed.)	(Lines 545 - 547): Tutor: So have you got out of the course what you hoped to get? Student: Yes. It's good. I did expect it to be much harder, but, I suppose that's a positive thing.
9		My mathematics skills have been reborn & touched up. I have a good understanding with most of the topics we covered & feel comfortable in a mathematics situation.	(Lines 636 - 637): Student: Yes, an all round general knowledge of basic maths skills and to prepare me for the foundation year in engineering.

	Start: What do you expect to gain from this summer school?	Finish: What benefit do you think you have gained from this course?	Interview Transcript is given in Appendix G
10		The course helped ready me for Lectures and Uni life. It made the start of the foundation year a lot gentler and I would recommend it to all mature students regardless of their previous achievements [sic].	<p>(Lines 730 - 741):</p> <p>Tutor: Can you tell me generally what benefit do you think you've got from the course?</p> <p>Student: I am certain that every presentation I have received completely concreted my knowledge of the subject. I don't think I learnt very much but what I already had learned was really reinforced by the course.</p> <p>Tutor: You were fairly confident in most of this stuff beforehand? Is that reasonable to say?</p> <p>Student: Yes, but only because I'd done the actual revision book before I arrived. So I'd done the exact course content before I came.</p> <p>Tutor: You got some benefit then?</p> <p>Student: I am positive every presentation I saw was worthwhile.</p>
11	Brush up on principles	It has helped me a great deal over the first month of the pathways course and I think that reflects on comments from other students who say that they wished they had attended and feel that we've had a head start on the maths module. I just wish there had been a summer school for computers !	

	Start: What do you expect to gain from this summer school?	Finish: What benefit do you think you have gained from this course?	Interview Transcript is given in Appendix G
13		The maths summer school is an awesome course to do prior to the Foundation Pathway. Being a mature student it has been good to get my brain back in gear.	
14		Lots more confidence with maths. Before I came on to the course I truly believed I couldn't do maths at all but I'm [sic] amazed at how much I seem to have taken in in such a short space of time. It has changed my attitude to maths completely.	
15		I think I have gained a higher understanding of maths which I greatly need.	

Table 4.42: Comparison of expectation and achievement

4.8 Conclusion to chapter

The students on the summer school formed a diverse group, both in terms of age and mathematical qualifications. The stated expectation of almost all students involved improvement and/or consolidation of mathematical skills. All students have expressed at least some degree of satisfaction with the summer school: some have expressed a very high degree of satisfaction.

Computer-based presentation materials were used extensively on the summer school. Acknowledgement of their benefits, definite enthusiasm from some students for their use and the absence of disapproval suggests that their use was at least appropriate.

In the next chapter profiles of students are generated from the data in this chapter. Assessment is made of how well each student has engaged with the subject and the influence of the use of computer-based learning material in the classroom is assessed.

Chapter 5: Analysis of the data

5.1 Introduction

The research question is: How can technology be used in the mathematics classroom to facilitate constructive alignment?

Constructive alignment is a design for teaching calculated to encourage deep engagement (Biggs 2003, p32).

In this section the responses from each student in turn are analysed for evidence of constructive alignment and for the influence of the use of computer-based presentation material.

The factors pertinent to constructive alignment are the student, the tutor, the learning environment, the ethos of the institution and the assessment system. The purpose of the analysis is to find evidence of compatibility or conflict between the student and these factors. As already discussed in Chapter 3, constructive alignment is more amenable to qualitative assessment than quantitative measurement.

For each student a brief profile is compiled from his or her initial survey. The summer school feedback questionnaire, the interview transcript and students' performance are analysed for indications of compatibility or conflict among the factors; for indications of engagement with the subject; and for evidence of the influence of the use of technology.

Of the fifteen students who enrolled on the summer school, twelve accepted the invitation to complete the initial questionnaire and to be interviewed. Due to personal circumstances unrelated to the summer school, one student

(ID 12) decided to leave on the 3rd day. Three students (IDs 7, 10, and 11), having worked through the material at their own pace, successfully completed the end-of-course test before the allocated two weeks.

For five of the students (IDs 3, 8, 9, 14, and 15), the offer of a place on the Foundation Pathways in Technology course was dependent on satisfactory performance on the summer school. The other ten had been offered places on the Foundation Pathways in Technology course, and were attending the summer school in preparation.

One student (15) showed symptoms of dyslexia: he often found difficulty with concepts and/or processes that he appeared to have assimilated at an earlier stage. He had never been assessed for dyslexia, but by co-incidence, in a context unrelated to the summer school, the possibility of being dyslexic had recently been suggested to him. During the summer school this student made arrangements to undergo formal assessment for dyslexia.

5.2 Analysis of students

5.2.1 Student 1

Student 1 was a prospective engineering student, aged 48. He had not recorded any formal mathematics qualification but had gained a grade B 'O' Level in physics at the age of 16. At school he mostly enjoyed mathematics, usually liked solving problems and felt himself to be in the top half of the class as far as mathematics was concerned. He considered that a good memory and understanding were necessary to be good at mathematics but was not sure whether a good teacher was necessary. He recalled no particular experiences which made him like or dislike mathematics.

This student had been offered an unconditional place on the Foundation Pathways in Technology course.

There was no part of the summer school which he found particularly difficult, although he did indicate some diffidence with respect to indices. Asked if he found any topic or part of the summer school particularly difficult, he replied, *"No, I just had a slight problem with the indices, that was all. Thinking about that, everything else was ok."* (Appendix G: Interview transcript lines 5, 6).

Asked to comment on any topic areas which stood out (Interview transcript line 7 onwards) he used the words, *"helpful"*, *"useful"* and *"quite useful"*. His interview (transcript lines 9 to 25) indicated that he found visual aids of benefit, *"being able to visualise the graph, how it changed and so on"* (Interview transcript lines 10,11).

This student considered that the visual aspects afforded by the computer-based presentation material are beneficial. Asked if any topic areas stood out in this respect, he replied, *"Certainly I found the graph stuff helpful, doing it with the computer technology, being able to visualise the graph, how it changed and so on ... being able to alter the gradient and coordinates and see the gradient come through ... just being able to visualise the equations from the graphs. Trigonometry as well I found useful ... Just to be able to imprint it on my mind"* (Interview transcript lines 9 – 25).

In response to question 4 on the feedback questionnaire, the student identified four topic areas for which the presentation particularly helped his understanding. The aspect that made them particularly helpful was given as *"tutors [sic] demonstration on interactive board"*. In responses to both

question 4 and question 8, trigonometry was cited as a topic/session which was particularly effective. The reason given was that it was "*well explained*". As the explanation involved the use of computer-based presentation material it may be reasonable to attribute some benefit to this aspect, although it may not be major.

Question 9 asked specifically whether the computer-based presentation material was considered to be helpful. The student ticked 'Yes' for seven topics and 'Don't know' for the other three topics. No comment was made. One of the 'Don't know' topics was fractions, which was also selected in question 4 as a topic where the presentation was particularly helpful to understanding.

At the start of the summer school Student 1 felt "*a bit rusty about maths*" and hoped the summer school would give him "*more confidence*" (Initial questionnaire, question 11). At the end of the summer school he stated, "*I'm very confident, much more confident now*" (transcript lines 49/50).

Although a little diffident, he performed competently on the summer school scoring an average of 84% on the daily tests and 100% in the end-of-course test.

Apart from the possible anomaly of the student showing evidence of both diffidence and competence, there was no indication of significant conflict between this student and the other factors involved in constructive alignment.

For this student some benefit from the use of computer-based presentation materials is evident. The benefit appears to have come from the way they were used to assist explanation.

5.2.2 Student 2

Student 2 was a prospective mathematics student aged 30. He had gained a grade B GCSE in mathematics four years previously. At school he mostly enjoyed mathematics, did not mind solving problems and usually liked specific questions. He felt himself to be in the top half of the class as far as mathematics was concerned. To be good at mathematics, he did not consider that a good memory was necessary, did not consider that a good teacher was necessary, but considered that understanding was necessary. He recalls no particular experiences which made him like or dislike mathematics.

This student had been offered an unconditional place on the Foundation Pathways in Technology course.

Asked if there was any topic on the summer school which he found particularly difficult, this student replied, *"No, not really"*, and confirmed, *"Yes"* when asked if he was fairly confident with most topics before starting the summer school (transcript lines 58 - 64). From the summer school he expected to *"Refresh my knowledge and maybe learn a bit more"* (Initial questionnaire question 11). Asked if he had achieved this he replied, *"Yes, definitely"* (transcript line 138), and added *"It's accomplished what I hoped it would"* (transcript line 144/5). He considered the presentation of fractions *"set out quite well"* (transcript line 71) and although he did not have difficulty with fractions the session was of benefit to him. He recalled, *"The way the grids are going and the addition and the multiplication I think as well - yeh - you can just see it easier - I mean I can do it anyway - but the way it's split vertically*

and horizontally on these grids...You could visualise it more. Rather than just use numbers, you could visualise it I think" (transcript lines 74 - 84).

Asked if he liked to visualise things, he replied, *"I think you get a better understanding of it if you can visualise it. So it helped me probably get a better understanding"* (transcript lines 85 - 89).

Having attempted to revise transposition of formula from textbooks on his own, he expressed satisfaction with the coverage of the topic on the summer school, *"I was looking through some textbooks and I forgot how to do some of this transposition. I would move it around and it would be in the wrong places. So I found this very useful really"* (transcript lines 102-105). He was similarly appreciative of the coverage of indices and graphs stating, *"I got a lot from that"* (transcript lines 114 - 126).

Commenting on the use of the computer-based presentation material for fractions, this student considered it *"useful"* and *"set out quite well"*, which enabled him to *"just see it easier"* (transcript lines 69-71). Although he was already content with his knowledge of fractions he considered that the visual representation provided a *"better understanding"* (transcript lines 76-87).

He was glad that transposing formulae was covered in the summer school, as his attempt to revise this from textbooks had not been entirely satisfactory. Electronic presentation was used extensively for this topic, coverage of which he acknowledged as being *"very useful really,"* (transcript line 105) but he was uncommitted as to whether the electronic presentation had advantages over presentation using a conventional whiteboard, saying, *"I don't know if it would have made much difference doing it on the projector or if you just did it on the*

board" (transcript lines 105/6). Asked if he would have a preference between an electronic presentation and a conventional whiteboard for any courses he might attend in the future he replied, *"No, I wouldn't be bothered. I don't think it would make much difference to me – not really"* (transcript lines 112/3).

In question 8 of the feedback questionnaire he identified graphs as a topic/session which was particularly effective, commenting that he had not *"covered this since school"*. This was amplified in the interview when he said, *"Graphs, graphs, this is something that I couldn't remember how to do ... I spent the weekend last weekend going through it ... Working out the equation from graphs. I forgot how to do that. I got a lot from that"* (transcript lines 120-125). The classroom presentation of this topic used computer-based material: the student had spent time, at home, revising from the summer school booklet. Asked if he was referring to the computer-based presentation material or the revision booklet, the student replied that he was referring *"definitely"* to both (transcript line 129). Then, asked if he found that the computer-based presentation materials used in the classroom complemented the booklet he responded, *"Yeh, I think they were complementary, definitely on graphs, and trig"* (transcript lines 131-132).

This student's motivation was already high before joining the summer school and he was enthusiastic about the summer school (transcript lines 153 - 157). The experience seems to have consolidated and enhanced his skills and knowledge of the subject. He described his disposition to mathematics as *"confident"* and *"comfortable"* (transcript lines 153 - 157). On the daily tests he scored an average of 90% and on the end-of-course test he scored 93%.

Although he expressed no preference between the electronic medium and conventional presentation using a whiteboard this student was amenable to the way ICT was used, and appeared to have derived some benefit in terms of consolidation/renewal of existing/former knowledge. There is a suggestion that the benefit was related to visual illustration.

This seems to suggest a positive degree of constructive alignment.

5.2.3 Student 3

Student 3 was a prospective engineering student aged in his mid 30s. He held a CSE grade 3 in mathematics, gained at the age of 16. At school he rarely enjoyed mathematics but did not mind solving problems or answering specific questions. He felt himself to be in the bottom half of the class as far as mathematics was concerned. To be good at mathematics, he considered that a good teacher and understanding were necessary, but did not consider that a good memory was necessary. He could recall a particular experience that made him like mathematics, although he did not disclose what it was.

This student had been offered a place on the Foundation Pathways in Technology course conditional on successful performance on the summer school.

From the summer school Student 3 expected to gain a much better understanding of mathematics and to overcome previous fears of tackling equations (Initial questionnaire question 11). He reported that he *"did have trouble"* with graphs and indices but adds that, *"it's not as hard as I thought it was"* (Transcript lines 164-171). He reported having a *"much better understanding of basically everything in the course"* (Transcript lines 206).

This student identified three topic areas where the presentation was particularly helpful to understanding (feedback questionnaire question 4). Aspects which made them particularly helpful were that the revision booklet was "very clear" and the "screen projector was useful especially for trigonometry". Question 13 asked about the role of the tutor, to which the student responded, "Tutor was very good at explaining problems and always had time for people struggling".

Question 9 of the feedback questionnaire asks specifically whether the use of computer-based presentation material was found to be useful. While acknowledging that the computer-based material offered benefits, the student thought that *"a mixture of computer and blackboard [sic]... would achieve the best results"*. This point of view was affirmed in the interview, *"I would prefer a mixture. I feel that there is a lot to be gained from the projector and also there's a lot that would be lost in a classroom without the blackboard methods being used in certain occasions"* (transcript lines 240-242). Asked to identify benefits offered by the use of computer and projector, he responded, *"The questions can be put over more accurately"*.

This student had identified three factors of teaching and learning which he considered to have contributed to the effectiveness of the summer school: resources, presentation and the role adopted by the tutor. He did not indicate any ranking or weighting of these factors.

He appears to have accepted the role of computer-based resources within the summer school, which he considered to have raised his level of confidence in

tackling mathematical problems by "100%" (feedback questionnaire question19).

On the daily tests he scored an average of 92% and on the end-of-course test he scored 100%.

Asked if his expectations of the summer school had been achieved he replied, *"Absolutely, absolutely. As I say, I came here with nothing, and since 1984 – was the last time I did any maths at school and I didn't do very well then either, – so basically, everything that I've learned about maths I've learnt in this two weeks"* (Transcript lines 254 - 257). This emphatic endorsement suggests a positive degree of constructive alignment.

It seems reasonable to conclude that this student benefited from the summer school, in which the use of computer-based presentation material was an integral part. The benefit to the student from the use of electronic resources appears to be related to visual impact.

5.2.4 Student 4

Student 4 was a prospective mathematics student in her late 30s. At school she gained an 'O' Level Grade B in mathematics which she mostly enjoyed. She usually liked solving problems and felt herself to be in the top half of the class as far as mathematics was concerned. She considered that a good memory and a good teacher were necessary to be good at mathematics, and also considered that it was not necessary to understand mathematics as long as the rules or formulae were known. She could recall a particular experience that made her like mathematics.

This student had been offered an unconditional place on the Foundation Pathways in Technology course.

Student 4 did not cite any topic as being particularly difficult in response to question 1 of the feedback questionnaire. Nominating indices as relatively the most difficult topic (transcript lines 266 - 268), she reported, *"I think it was a case of learning the rules and understanding why we did what we did. I am a lot clearer on it now"*.

The session on fractions was less successful for this student. *"I just couldn't get this grid idea at all. If anything, that actually confused me more"* (transcript lines 290/1). She was able to perform arithmetic involving fractions competently and found no problems with fractions. Before the summer school, however, she was unaware that multiplication and division took precedence over addition and subtraction and identified that ignorance of this had led to *"making silly mistakes over the past years"* (transcript line 299 - 308).

Before the summer school this student was hesitant about undertaking a degree in mathematics. At the end of the summer school she felt *"a lot better, a lot more confident"* (transcript lines 317/8) and had, *"Definitely, without a doubt"* (transcript lines 325) got her *"brain into gear"*, which was her stated expectation of the summer school (Question 11 of initial survey).

For this student, the relatively most difficult topic was indices although no topic presented great difficulty. Asked if she found any part of the summer school particularly difficult, she replied, *"Not really, really difficult, but the hardest bit for me was indices. Everything else was OK"* (transcript lines 263/4). She acknowledged that the computer-based presentation material on

this topic area was beneficial, *"Yes that was good, yeh, that was OK. That helped on indices"* (transcript line 275).

The succinct computer-based presentation on order of precedence of arithmetic operations appears to have been effective as the student was unaware of, or had forgotten, this convention prior to the summer school. Asked if the presentation had helped, she replied emphatically, *"Yes, totally. Yes, totally."* (transcript lines 307).

Earlier in the interview this student had stated, *"I was a little bit put off by the computer"*. The reason given for the aversion, *"my eyesight isn't brilliant, but I'm rather loath to wear my glasses,"* (transcript lines 280/1) is relevant to all visual presentation media. The student confirmed that she made frequent use of a computer at home (transcript lines 286/7). Probed for further reasons for aversion to the use of the computer, she stated that she considered the computer-based presentation material for fractions to be confusing, *"If anything, that actually confused me more"* (transcript lines 291). She also suggested, however, the possibility that as she was content with her ability to work with fractions, she was not receptive to an alternative perspective (transcript lines 292/3). This suggests a difficulty related to the concept that was being presented rather than to the medium.

There are indications that this student may place greater importance on remembering procedures than on understanding, which might inhibit deep engagement with the subject. This implies imperfect constructive alignment with the aims of the summer school, which include the development of understanding. She did feel, however, that she had benefited from the

summer school and refers to "*understanding why we did what we did*" (transcript lines 267/8). Her daily test scores indicate that she can competently perform mathematical calculations: she scored an average of 94%. Due to personal circumstances and the fact that an unconditional place had been offered on the Foundation Pathways course, she opted not to attend for the end-of-course test on the final day.

There appears to be at least a mild degree of constructive alignment.

While this student may not have volunteered strong endorsement of the use of computer-based presentation materials, neither did she strongly deprecate their use. Although she did not benefit from the presentation on fractions, she acknowledged benefit from other presentations. The benefit appears to be related to visual impact.

She considered that overall the summer school had, "*without a doubt*", fulfilled her expectations (transcript lines 325).

5.2.5 Student 5

Student 5 was a prospective mathematics student aged 28 who gained a GCSE grade B in mathematics at school, where he mostly enjoyed mathematics and usually liked solving problems. He felt himself to be in the middle of the class as far as mathematics was concerned. To be good at mathematics, he considered that a good teacher and understanding were necessary but was not sure that a good memory was necessary. He recalled no particular experiences which made him like or dislike mathematics.

This student had been offered an unconditional place on the Foundation Pathways in Technology course. Due to personal commitments he did not attend the final two days of the summer school. Although he consented to be interviewed, a convenient time could not be found to conduct the interview. In response to question 4 of the feedback questionnaire he writes that *"Good communication with the tutor"* was an aspect which made the presentation of eight of the ten topics particularly helpful to understanding. In response to question 8 he acknowledged that, *"The topics are presented in a way which relates to each other"*.

On the daily tests he scored an average of 80%.

This student was not available for interview and his responses to the feedback questionnaire were few and brief. In response to question 9, which asked directly about the use of computer-based presentation materials, he indicated that this was helpful for five of the ten topics, and commented, *"Computers are useful, but could be made more useful."*

Good communication implies engagement, which indicates a positive degree of constructive alignment. The analysis seems to imply a liking for the use of computers and a greater expectation from their use.

5.2.6 Student 6

Student 6 was a prospective engineering student aged 24. At school he sometimes enjoyed mathematics, usually liked solving problems and gained a GCSE grade C in mathematics. He felt himself to be in the top half of the class

as far as mathematics was concerned. To be good at mathematics, he considered that a good memory, a good teacher and understanding are all necessary. He could recall no particular experience that made him like or dislike mathematics.

This student had been offered an unconditional place on the Foundation Pathways in Technology course.

He did not find any topic in the summer school to be particularly difficult but considered fractions to be relatively the most difficult stating; *"I wouldn't say I found them particularly difficult. I think the hardest part on the course was definitely the fractions part"* (transcript lines 332/3). This appears to be due to deficiency in the skills of multiplication and division of integers rather than the concept of fraction. Although he thought that the diagrams *"confused the issue slightly"* (transcript lines 358), he felt *"Far more confident"* (transcript lines 346) with the topic by the end of the summer school.

Another area where he found initial difficulty was in transposition of formulae: He stated *"rearranging formula has always been the part, that if anything was likely to go wrong that would be the part that would go wrong"* (transcript lines 372-374). For him, the summer school had *"certainly cleaned that up"* (transcript line 375) and given him a *"clearer understanding of what's actually happening"* (transcript lines 383/4).

In response to the feedback questionnaire this student identified the topic, rearranging formulae, as one where the computer presentation was particularly helpful. What made it helpful was *"the explanation on how to do it one step at a time"* (question 4). He described it as his *"most inconsistent area"*

of maths" (question 8). His reaction to the presentation was, "*It's good*", (transcript lines 380) and it had given him "*a far clearer understanding*" of the topic (transcript line 383). This is the only topic to which he responded in question 9 of the feedback questionnaire. Question 9 asked, whether the use of computer-based presentation material by the teacher was helpful. Respondents were asked to indicate 'Yes', 'No' or 'Don't know' for each of ten topics. For this topic he indicated, 'Yes'; for the other nine topics he made no indication. He added the comment, "*Also the software on logs was very helpful.*"

His response to the use the material on fractions was less favourable, but the criticism was directed towards the content rather than the medium. He considered the diagrams to be confusing and unnecessary; "*I don't think the diagrams are necessary, to be honest. I think they confuse the matter*" (transcript lines 362/3); but he did not object to the numerical part of the demonstration; "*Personally I think the numbers and the methods shown there are quite adequate on their own*" (transcript lines 364/5).

He made no objection to the use of computer-based resources and in response to question 4 of the feedback questionnaire he offered a firm endorsement of their use in a particular instance. The question asked respondents to identify topics where the presentation was particularly helpful to understanding, and to identify aspects of the presentation which made it so. This student identified one topic and considered that, "*The explanation on how to do it one step at a time*" was an aid to understanding.

Asked in the feedback questionnaire what he had gained from the summer school this student replied that it had given him "a *great confidence boost*" and made him "*realise what a friendly place the University is*" (question 19).

On the daily tests he scored an average of 95% and on the end-of-course test he scored 100%.

This analysis suggests a positive degree of constructive alignment.

5.2.7 Student 7

Student 7 was a prospective student of computing, aged 25. At school he sometimes enjoyed mathematics, did not mind solving problems and usually liked specific questions. He had gained a GCSE grade C in mathematics and had felt himself to be in the middle of the class as far as mathematics was concerned. To be good at mathematics, he considered that a good teacher was necessary but was not sure that a good memory was necessary. He considered that it was not necessary to understand mathematics as long as the rules or formulae were known. He could recall a particular experience that made him dislike mathematics.

This student had been offered an unconditional place on the Foundation Pathways in Technology course.

He opted to take the end-of-course test at the beginning of the second week and did not attend for the remainder of the summer school.

There were no topics which he found particularly difficult although he was initially a little apprehensive and believed his mathematics skills to be poor; "*Initially I feared some of the topics but once I understood the rules that made*

it a lot easier for me to understand" (transcript line 419/20); *"I thought my maths skills were poor which was really a reflection of the fact that I hadn't used them for so long"* (transcript line 469/70). Asked in the initial survey (question 11) what he hoped to gain from the summer school he indicated that he wanted to *"Brush up maths skills"*. In the interview he confirmed that this had been achieved. He confirmed that he understood the topics which had been covered; *"I think that where I thought that I was bad at maths before, it was that I'd forgotten about certain rules and ways of doing things, and then once I re-learnt that, and it came back to me, then I was better at doing it"* (transcript lines 421-424); *"I now understand them"* (transcript line 492).

On the daily tests he scored an average of 81% and on the end-of-course test he scored 78%.

Question 9 on the feedback questionnaire asked whether the use of computer-based presentation material by the teacher was helpful. This student selected 'Yes' for nine of the topics and 'Don't know' for the remaining topic. Asked in the interview to explain in what way they were helpful, he responded, *"You could easily break it down into steps and you could see what was going on"* (transcript lines 454/5). Describing the benefit he gained from the summer school, he wrote, *"When I started I thought my maths was poor, but now I know I was just out of practice"* (feedback questionnaire question 19).

This analysis suggests that the presentations were beneficial in providing effective summaries, clarification, and consolidation and that the degree of constructive alignment was positive.

5.2.8 Student 8

Student 8 was a prospective mathematics student, aged 26. At school he mostly enjoyed mathematics, liked solving problems and usually liked specific questions. He felt himself to be in the top half of the class as far as mathematics was concerned but disclosed no formal qualification in mathematics. To be good at mathematics, he considered that a good teacher and a good memory were necessary. He also considered that it was not necessary to understand mathematics as long as the rules or formulae were known. He could recall no particular experience that made him like or dislike mathematics.

This student had been offered a place on the Foundation Pathways in Technology course conditional on successful performance on the summer school.

He considered that he had probably covered all of the topics at school but could not remember them and felt that he was starting from the beginning: *"I've probably done it all of this before but it's been like ten years. I can't remember anything. I feel like I am starting from the beginning"* (transcript line 521-523).

He was initially a little apprehensive; *"I was a bit scared of coming at first but it's OK, it's good"* (transcript lines 541/2); but found the resources useful: *"...everything I learnt really, is from the revision book"* (transcript line 510); *"Yes, I used [the CD] at home, just to go through things, just a recap on what I've done, ready for the test really"* (transcript lines 533/4) and felt that his *"brain has got back into exercising"* (transcript line 543/4).

In his feedback questionnaire, in response to question 18, which asked for comments on the assessment methods, he suggested that his progress was impeded by the slower pace of other members of the group. His final mark was 94%, comfortably above the group average of 83%.

In the feedback questionnaire this student selected all ten topics as being presented in a way that was particularly helpful. The aspect which made presentations helpful he described as, *"the teacher explaining and helping you"*, which *"makes things simpler"* (question 1).

Question 9 asked specifically whether the computer-based material used in the presentations was found to be helpful. The student selected 'Yes' for all ten topics and added the comment, *"It showed the correct step by step process to getting the answer. It was very clear which helped my understanding of each topic"*.

In the interview Student 8 specifically mentioned that he liked the graphic illustration of fractions: *"I think the fractions one was quite good because it actually showed the fraction in graphic sense rather than a number. It showed, say for example if it was a quarter, it showed a quarter of something"* (transcript lines 496-498).

Referring to the computer-based material on equations he commented, *"I did like the way that it showed everything step by step and explained it really well"* (transcript lines 502/3).

He also expressed a preference for the medium of electronic projection over conventional use of a whiteboard stating, *"it shows everything clearly and it's*

good to see it on computer rather than just written up, I think. It looks better"
(transcript lines 527-529).

Use of computer-based presentation material clearly suited this student. The aspects which appealed to this student are the decomposition of processes into steps and visual representation.

On the daily tests he scored an average of 96% and on the end-of-course test he scored 93%.

Although this student's response to question 18 of the feedback questionnaire indicates that he may have been able to meet greater challenges than those presented by the summer school, his attainment and re-familiarisation with mathematics suggest positive constructive alignment.

5.2.9 Student 9

Student 9 was a prospective engineering student, aged 21. At school he sometimes enjoyed mathematics, did not mind solving problems, did not mind specific questions, and felt himself to be in the middle of the class as far as mathematics was concerned. To be good at mathematics, he did not consider that a good memory was necessary and was not sure that a good teacher was necessary. Also, he considered that it was not necessary to understand mathematics as long as the rules or formulae were known. He could recall a particular experience that made him like mathematics. He disclosed a GNVQ level F, but no formal qualification in mathematics.

This student had been offered a place on the Foundation Pathways in Technology course conditional on successful performance on the summer school.

On his feedback questionnaire (question 1) and in the interview he identified fractions as an area of difficulty and in the interview he confirmed "*I found fractions difficult and still am having a few problems. I just can't get to grips with the concepts*" (transcript lines 554/5). In the topic test on fractions he scored 5 out of 20. On a retest with a similar paper he scored 10 out of 20. In the end-of-course test, covering all topics, he scored 4 out of 6 for the question on fractions. In response to question 4 in the feedback questionnaire he felt that all topics were "*explained properly*" and "*taught well*", although he felt that fractions was "*rushed a bit*".

In response to question 4 of the feedback questionnaire this student selected nine out of the ten topics as being presented in a way that was particularly helpful. He considered that the topics were, "*explained properly and taught well*" and that, "*the computer & the projector made it a lot easier to understand*". In responses to questions 8 and 9 he indicated that he also made use of the software for revision at home and described it as "*very effective*".

Commenting on the software used to illustrate transposition of formulae, he said, "*it shows you step by step what's happened*" and, "*so it was quite easy to understand*" (transcript lines 605/6).

At the start of the summer school he was unaware of, or had forgotten, the order of precedence of arithmetic operations: "*It's never come across me before. First time*" (transcript line 571). Recalling the presentation he said, "*it*

was easy to understand and made it clear" (transcript lines 579-580), and he confirmed his satisfaction that he would be able to apply the rules in the forthcoming test, "Yes" (transcript line 584).

Asked if the presentations would have been just as effective had they been written on the board, he responded, *"I suppose so, but with the software you saved a lot of time"* (transcript line 609). Then asked if he had a preference, he initially replied, *"Honestly it doesn't make a difference"* (transcript line 623), but after some consideration stated, *"I preferred the projector to the board"* (transcript line 623), *"It was all laid out for you. You didn't have the teacher moving from one side of the board to the other trying to explain something. It was there; all done for you and step by step what you wanted; you could always go back and could go forward"* (transcript line 629 - 632)

Use of computer-based presentation material appears to have been appropriate and beneficial for this student. Understanding had been assisted by step-by-step illustration.

Overall he felt that his *"mathematics skills have been reborn & touched up"*; he had *"a good understanding with most of the topics"* and he felt *"comfortable in a mathematics situation"* (feedback questionnaire question 19). This point of view was confirmed in the interview. Asked what he had gained from the summer school he replied, *"an all round general knowledge of basic maths skills"* (transcript lines 636/7).

On the daily tests he scored an average of 65% and on the end-of-course test he scored 93%.

This analysis suggests a positive degree of constructive alignment.

5.2.10 Student 10

Student 10 was a prospective engineering student, aged 24. At school he mostly enjoyed mathematics, usually enjoyed solving problems and did not mind specific questions. He felt himself to be in the middle of the class as far as mathematics was concerned. He disclosed no formal qualification in mathematics but gained a GCSE grade C in science. To be good at mathematics, he considered that a good teacher and understanding were necessary but did not consider that a good memory was necessary. He could recall a particular experience that made him like mathematics.

This student had been offered an unconditional place on the Foundation Pathways in Technology course.

Having worked his way through the course booklet before the start of the summer school, he found little difficulty with the summer school. Asked if he had felt confident with the summer school content, he replied, *"Yes, but only because I'd done the actual revision book before I arrived. So I'd done the exact course content before I came"* (transcript lines 738-9).

On the daily tests he scored an average of 84% and at the start of the second week he took the end-of-course test early and scored 100%. It was thus not necessary for him to stay until the end of the summer school.

Asked whether he had benefited by attending the summer school, he replied, *"I am certain that every presentation I have received completely concreted my knowledge of the subject. I don't think I learnt very much but what I already had learned was really reinforced by the course"* (transcript lines 732 - 735).

In the feedback questionnaire (question 19) he recommended the summer school to *"all mature students regardless of their previous achievements"*.

In response to questions on the feedback questionnaire this student wrote; *"For presentation the computer based material was good but a remote mouse may have been useful"* (question 9); *"The fractions lesson was very effective"* (question 8); and *"I liked the kangaroo it really helped me get my head around negative multiplication"* (question 4).

At various points in the interview he described parts of the presentation software as *"beautiful"* (transcript line 675), *"great"* (transcript line 676), and *"fantastic"* (transcript line 679). He was critical of some of the software, but his criticism was constructive; he suggested modifications and developments. He was not averse to, but showed enthusiasm for its use: *"you can see on this page, we had ... but what I want then would have been ..."* (transcript lines 693/4); *"... more profound colour would be good. So perhaps for every operation you make that a very bright red"* (transcript lines 688 – 690); *"if it would be possible to display that on a whiteboard instead of a screen, I think that would be great ... then ... actually being able to just write over what you've got from the computer, with your hand"* (transcript lines 760 - 770).

The use of computer-based presentation material seems to have been very appropriate and effective in consolidating this student's knowledge. His engagement with the summer school materials and suggestions for development suggest very positive constructive alignment.

5.2.11 Student 11

Student 11 was a prospective mathematics student, aged 44 and holds a Higher National Certificate in engineering. At school he mostly enjoyed mathematics and did not mind solving problems. He gained a GCSE grade C in mathematics and felt himself to be in the top half of the class as far as mathematics was concerned. To be good at mathematics, he considered that a good teacher and a good memory were necessary. He also considered that it was not necessary to understand mathematics as long as the rules or formulae were known. He could recall a particular experience that made him like mathematics and a particular experience that made him dislike mathematics.

This student had been offered an unconditional place on the Foundation Pathways in Technology course. His aim in attending the summer school was to "*Brush up on principles*" (Initial questionnaire question 11) and he found the summer school well within his capabilities. At the beginning of the second week he scored 98% in the end-of-course test and did not attend for the remainder of the summer school.

This student was not interviewed and he submitted his feedback questionnaire after he had commenced on the Foundation Pathways course.

He considered that all topics were explained and presented well and was happy with his understanding of them (feedback questionnaire question 2). Coverage of three topic areas in particular he found "*very useful*" as he had not studied them for some time (feedback questionnaire question 8).

This student was appreciative of an introduction to two topic areas which were not on the original syllabus and would like to have had more time on these

areas. These were use of a graphics calculator, (feedback questionnaire question 4), and logarithms (feedback questionnaire question 6).

Responding to question 19, he declared that the Summer School helped him *"a great deal over the first month"* of the Foundation Pathways course.

This student was very able and had relatively high academic qualifications (HNC in Engineering). On the daily tests he scored an average of 81%. He took the end-of-course test early and scored 98%.

Question 9 of the feedback questionnaire asked whether the computer-based material used in the presentations was found to be helpful. This student selected 'Yes' for all ten topics.

In response to question 4 he selected 5 topics for which the presentation was particularly helpful but did not indicate which aspects made this so.

None of his comments on the feedback questionnaire expressed specific endorsement of or dissatisfaction with the use of computer-based material.

It seems that this student was amenable to the way in which computer-based material was used and that the benefit he derived from the summer school was a refreshing of mathematical skills.

This analysis suggests positive constructive alignment.

5.2.12 Student 12

Student 12 was a prospective engineering student. At school he rarely enjoyed mathematics but did not mind solving problems. He felt himself to be in the middle of the class as far as mathematics was concerned. He disclosed no

formal qualification in mathematics. To be good at mathematics, he considered that a good teacher, a good memory, and understanding were necessary. He could recall no particular experience that made him like or dislike mathematics.

This student withdrew from the summer school on the third day for personal reasons unconnected to the summer school.

5.2.13 Student 13

This student had been offered a place on the Foundation Pathways in Technology course conditional on successful performance on the summer school.

Student 13 did not participate in the initial survey or in an interview but submitted a summer school feedback questionnaire. He holds a grade D GCSE in mathematics from school.

In the feedback questionnaire he identified one topic area, fractions, that he found particularly difficult (question 1). His response to question 1 included a comment that, *"The amount of help available was excellent."* In response to question 8 he identified all topic areas as being particularly effective. In response to question 13, (What benefit do you think you have gained from this course?), he described the summer school as *"awesome"*.

Question 9 of the feedback questionnaire asked whether the computer-based material used in the presentations was found to be helpful. This student selected 'Yes' for all ten topics and commented, *"Awesome, a great way to*

fully understand a topic". In response to question 4 he selected seven out of the ten topics as being presented in a way that was particularly helpful. He considered that, *"The use of IT was particularly helpful as it easily simplified each process"*.

To question 19, which asked what benefit had been gained from the course, the student responded, *"Being a mature student it has been good to get my brain back in gear"*.

This student appears to have derived considerable benefit in terms of revision and consolidation of existing knowledge.

On the daily tests he scored an average of 78% and on the end-of-course test he scored 100%.

This analysis seems to indicate a definite degree of constructive alignment.

5.2.14 Student 14

This student had been offered a place on the Foundation Pathways in Technology course conditional on successful performance on the summer school.

Student 14 did not participate in the initial survey or in an interview but submitted a summer school feedback questionnaire.

In the feedback questionnaire she identified three topic areas, fractions, negative numbers, and rearranging formulae, that she found particularly difficult (question 1). The topic, fractions, was identified again in question 8: Was there any topic where the presentation was particularly helpful to

understanding? Although in question 7 she identified two topics that could have been presented better, she commented "*it was presented ok but I felt that I just needed to practice [sic]*". Her responses to questions 1 and 2 also indicate a preference for more time to practise.

In question 8 she identified 3 topics for which she considered the overall presentation to be particularly effective. The effectiveness was attributed to, "*The way they were explained in both the book and its examples, and in the classroom*".

In the class test on fractions she scored 3 out of 20, and on the question on fractions in the end-of-course test, she scored 5 out of 6.

In response to question 4 of the feedback questionnaire this student selected 3 topics for which the presentation was particularly helpful; fractions; graphs and trigonometry. Asked what aspects made them helpful, she wrote, "*Using the board and the CDs on the computers helped to go through everything step by step which helped increase my confidence*".

Question 9 asked whether the computer-based material used in the presentations was found to be helpful. This student selected 'Yes' for six of the ten topics and 'Don't know' for the other four.

This student clearly derived substantial benefit from the summer school. It seems fair to suggest that the use of computer-based material was a contributing factor, as it was used extensively for whole-class teaching.

On the daily tests she scored an average of 47% and on the end-of-course test she scored 68%.

Question 19 of the feedback questionnaire asked what benefit had been gained from the summer school. In response she wrote, *"Lots more confidence with maths. Before I came on to the course I truly believed I couldn't do maths at all but I'm amazed at how much I seem to have taken in in such a short space of time. It has changed my attitude to maths completely."*

This seems to imply strong constructive alignment.

5.2.15 Student 15

This student had been offered an unconditional place on the Foundation Pathways in Technology course, deferred at his request for one year. Although he had no formal qualification in mathematics, he had an AS Level in Psychology and grade B AVCE in ICT.

He did not participate in the initial survey or in an interview but submitted a summer school feedback questionnaire.

In response to question 1 he identified seven of the ten topic areas which he considered to be 'particularly difficult'. The greatest number identified by any other student was three. The question also asked how the topics might have been made easier, to which he responded, *"more explanations in different contexts would have helped a great deal"*.

Question 7 asked whether there were any topics or sessions which could have been better presented, and in response he identified only one topic, fractions, commenting that, *"More time should have been spent on fractions"*.

On the daily tests he scored an average of 47% and on the end-of-course test he scored 48%.

During the summer school this student showed symptoms of dyslexia which were brought to his attention. As a result he was motivated to seek formal assessment for dyslexia.

Question 9 of the feedback questionnaire asked whether the computer-based material used in the presentations was found to be helpful. This student selected 'Yes' for three topics, 'No' for three topics and 'Don't know' for the other four.

He selected only one topic in response to question 4, where the presentation was 'particularly' helpful, but did not comment on what aspect(s) made it so.

In response to question 2 he identified seven topics which he could have understood better had they been presented differently, and commented that he would have preferred "*more examples and more ways of working them out*".

In response to question 19 he wrote, "*I think I have gained a higher understanding of maths which I greatly need*", and responding to question 14, he wrote that the individual support he received was "*very helpful*".

This student has obtained benefit from the summer school. Any contribution to this from the use of computer-based technology appears to be minor.

This student derived benefit from the summer school which may be taken to imply at least some degree of constructive alignment. He felt, however, that he needed more time to consolidate, and his scores corroborate this.

5.2.16 Summary of analysis of students

The analysis for each student is summarised in Table 5.1.

ID	Mean daily test Score %	End test Score %	Indications of constructive alignment / engagement	Indications of lack of constructive alignment / engagement	Beneficial effects attributable to use of computer-based presentation materials.	Negative effects attributable to use of computer-based presentation materials.
1	84	100	Is now much more confident	None reported or observed	Visual aspects assist explanation	None reported or observed
2	90	93	Has gained a better understanding; confident, comfortable	None reported or observed	Consolidation/renewal of existing/former knowledge; complementary to printed materials; visual illustration	None reported or observed
3	92	100	Not as hard as initially thought; now has much better understanding	None reported or observed	Benefit appears to be related to visual impact	None reported or observed

ID	Mean daily test Score %	End test Score %	Indications of constructive alignment / engagement	Indications of lack of constructive alignment / engagement	Beneficial effects attributable to use of computer-based presentation materials.	Negative effects attributable to use of computer-based presentation materials.
4	94	N/a	Learning the rules, understanding why we did what we did, a lot clearer on it now	Possible inclination towards learning processes rather than developing comprehension	Benefit appears to be related to visual impact	(Student was "...loathe to wear my glasses")
5	81	N/a	Good communication with the tutor - implies engagement	Few and brief responses on feedback questionnaire	Computers acknowledged as "Useful"	"Computers ... could be made more useful"
6	95	100	Far more confident; clearer understanding; a great confidence boost	None reported or observed	Breaking down of processes into steps is an aid to understanding	Use of diagrams for fractions considered to be confusing
7	81	78	Believed his maths skill to be poor; now understands Completed summer school early	None reported or observed	Effective summaries, clarification, and consolidation	None reported or observed

ID	Mean daily test Score %	End test Score %	Indications of constructive alignment / engagement	Indications of lack of constructive alignment / engagement	Beneficial effects attributable to use of computer-based presentation materials.	Negative effects attributable to use of computer-based presentation materials.
8	96	93	Brain has got back into exercising	May have found the summer school insufficiently challenging	Decomposition of processes into steps and visual representation	None reported or observed
9	65	93	Mathematics skills have been reborn & touched up; a good understanding; comfortable in a mathematics situation	None reported or observed	Understanding assisted by step-by-step illustration Software also used at home and described as "very effective"	Presentation on fractions not wholly satisfactory
10	98	100	Offers constructive criticism; suggests modifications and developments of summer school material Completed summer school early	None reported or observed	Consolidation: "Really reinforced" "very effective"; "really helped me get my head around"	None reported or observed

ID	Mean daily test Score %	End test Score %	Indications of constructive alignment / engagement	Indications of lack of constructive alignment / engagement	Beneficial effects attributable to use of computer-based presentation materials.	Negative effects attributable to use of computer-based presentation materials.
11	94	98	Very useful; helped a great deal Completed summer school early Refreshing of mathematical skills	None reported or observed	Material for all topics acknowledged as being helpful Specific aspects not identified	None reported or observed
12	Withdrawn from summer school					
13	78	100	Amount of help available was excellent; awesome; good to get my brain back in gear	None reported or observed	Revision and consolidation Simplification of processes	None reported or observed

ID	Mean daily test Score %	End test Score %	Indications of constructive alignment / engagement	Indications of lack of constructive alignment / engagement	Beneficial effects attributable to use of computer-based presentation materials.	Negative effects attributable to use of computer-based presentation materials.
14	47	68	Lots more confidence; how much I seem to have taken in in such a short space of time; changed my attitude to maths completely	A desire for more time to practise	The way things were explained is acknowledged as being effective	None reported or observed
15	47	48	A higher understanding of maths which I greatly need Identification of possible dyslexia	Low attainment compared to others in the group	Minor	None reported or observed

Table 5.1: Summary of analysis of students

5.2.17 Conclusions from the analysis of students

The engagement of each student with the subject is assessed in sections 5.2.1 to 5.2.15 and is summarised in Table 5.1, section 5.2.16.

While the motivation to engage with the subject was high before they joined the summer school, study of Table 5.1 indicates that all students who completed the summer school were better able to engage with the subject, than they were at the beginning of the summer school.

The assessment of students' engagement, through feedback questionnaires and interviews, shows that they were able to make critical appraisals of the content and the presentation of the summer school, thus demonstrating deep engagement, rather than surface engagement, with mathematics. In Table 5.5 the epitomising features in the summaries for nine of the students specifically include improved understanding and/or increased confidence (students 1, 2, 3, 4, 6, 7, 9, 14 and 15). For the remaining five students, mental engagement is implied. For example, student 13 found it *"good to get my brain back in gear"* and scored 100% in final test.

Although much of the content of the summer school is rudimentary, a degree of synthesis is engendered. For example, question 6 in the end-of-summer-school test (Appendix I) and Test 5, Graphs, (Appendix M), involve elementary mathematical modelling, which requires students to bring together skills and concepts from different topic areas.

Of the twelve students who took the tests, only two scored less than 68% (Students 14 and 15 scored respectively 57% and 47% - see overall scores in

Table 4.23). The pass mark was set at 40%. As stated in section 3.4.2.4, although high scores by themselves might not be indicative of deep engagement, they are an expected outcome of deep engagement.

The overall conclusion is that the summer school has enabled the students to engage more deeply with the subject of mathematics.

5.3 Analysis of topics

Three topics, which appear to have had the most significant impression on the group, have been chosen for closer analysis; order of precedence of arithmetic operations because of its fundamental importance and an apparent initial unawareness of the topic by students on the summer school, fractions because it was the most criticised topic, and rearranging formulae because the data seemed to indicate that this was the most effectively presented topic.

5.3.1 Order of precedence of arithmetic operations

Attention is drawn to this topic because of its fundamental importance and the fact that on the first day of the summer school none of the group showed confidence in applying the rules.

On the first day of the summer school the expression, $2 + 3 \times 4$, was written on the board and the students were asked to evaluate it. One student volunteered 20 as the answer. The others were invited to agree or disagree but were hesitant. Eventually another suggested 14 as a possible answer, but no one else was willing to express an opinion.

In interviews, four students confirmed their initial lack of familiarity with the rules. This is summarised in Table 5.2.

Student 2	Yes, but I can't really remember it – I mean I think I sort of did it without thinking about it but I think it was helpful that we went over that again (transcript line 94).
Student 4	Because now I can see where I'd been making silly mistakes over the past years and that is because of that BODMAS. I didn't know that before and that did really help (transcript lines 318-320).
Student 6	No, I didn't [know about BODMAS] (transcript line 401). Yeh, I'm happy with it now (transcript line 403). I think it was presented very well (transcript line 405) Yes, the rules about I'm happy (transcript line 413)
Student 9	No. It's never come across me before. First time (transcript line 593). ... it [the presentation] was easy to understand and made it clear (transcript line 602).

Table 5.2: Students' comments: order of precedence of operations

The presentation outlined in Chapter 3 was then given, demonstrating the convention for precedence. It took less than two minutes, at the end of which the whole group indicated that they were confident that they could now apply the rules.

The concise presentation on the rules for the order of precedence of arithmetic operations appears to have been effective.

5.3.2 Most criticised topic: Fractions

Question 7 of the feedback questionnaire asks, "Were there any topics or sessions which you consider could have been presented better?" Fractions was selected by 4 students; indices by 2 students, forming equations by one student and expanding brackets by one student. The question also invites respondents to give details of why the topic has been selected.

As fractions is the topic attracting most criticism, all references to the topics are now examined.

Data from the feedback questionnaire (questions 4 and 9) shows that 3 people (students 3, 8, 14) found both the presentation and the presentation material particularly helpful; two people (students 1, 5) found the presentation but not necessarily the material particularly helpful; and four people (students 7, 9, 11, 13) found the material but not necessarily the presentation particularly helpful. This is shown below as a Venn diagram in Figure 5.1. Figure 5.2 shows an example of the presentation material.

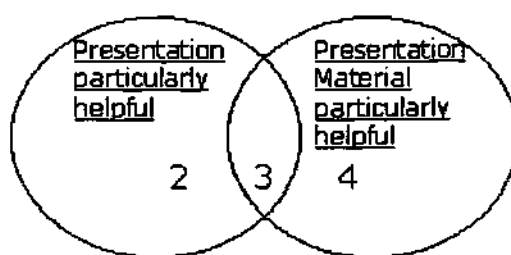


Figure 5.1: Number of responses relating the topic, Fractions

It is not anomalous that people selected one aspect and not the other.

Questions 4 and 9 asked respondents to identify respectively presentations

and presentation material that they considered had been particularly helpful. That respondents associated particular helpfulness with one aspect only, does not imply criticism of the other aspect. Figure 5.1 indicates that nine students acknowledged benefit from the presentation on fractions.

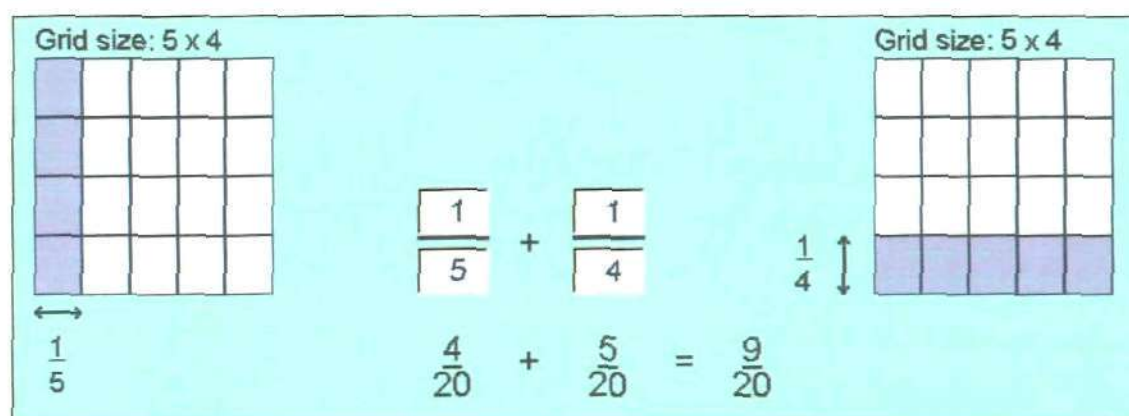


Figure 5.2: Example of presentation material for Fractions

Criticism is extracted from the feedback questionnaires and from interview transcripts and is shown in Table 5.3.

Student 4	<p>I just couldn't get this grid idea at all. If anything, that actually confused me more. But then, whether it was because I already was quite au fait with fractions and you were trying to teach me another method, if you like (transcript line 300-304).</p> <p>I knew how to do it before (transcript line 307-308).</p>
Student 5	<p>I still don't understand $x^{-\frac{1}{2}} = \frac{1}{\sqrt{x}}$</p> <p>Fractions & roots could be better connected to indices (question 7).</p>
Student 6	<p>I think long multiplication and long division should be included or run adjacent to this module. As sometimes the numbers are large and the ability to solve it without a calculator increases your understanding (question 7).</p> <p>I don't think the diagrams are necessary, to be honest. I think they confuse the matter. Personally I think the numbers and the methods shown there are quite adequate on their own (transcript line 376-379).</p>
Student 9	<p>The topic Fractions I feel was rushed a bit (question 4).</p> <p>Like I said before [I] felt that fractions was slightly rushed. Using the projector & certain software to show us how fractions work, but was showing to[o] much at any given time (question 7).</p> <p>It was easy to understand and it explained how the fractions worked, the size of them, what you take away (transcript line 580).</p>
Student 15	<p>More time should have been spent on fractions. Also more help should be given on the CD. More examples would help and also a few ways of getting an answer would help (Question 7).</p>

Table 5.3: Criticism of topic, Fractions

Support for the presentation and/or presentation material came from three students. This is shown in Table 5.4

Student 2	Rather than just use numbers, you could visualise it I think (transcript lines 83). So it helped me probably get a better understanding (transcript lines 87).
Student 8	I think the fractions one was quite good because it actually showed the fraction in graphic sense rather than a number. It showed, say for example if it was a quarter, it showed a quarter of something (transcript line 514).
Student 10	The fractions lesson was very effective (Question 7).

Table 5.4: Support for topic, Fractions

Student 4 and student 6 found the illustrations confusing; student 9 appears to have found them helpful to a limited degree; students 2 and 8 found them to be helpful. Student 10 does not say what made the lesson effective.

The criticism (Table 5.3) from student 5 is concerned with how the two topics, fractions and indices, relate to each other. It is also perhaps relevant that, as the reason for selecting four topics/sessions as being particularly effective, this student writes, *"The topics are presented in a way which relates to each other"* (feedback questionnaire question 8). Being able to relate topics to each other is clearly important to this student.

The difficulty exemplified by student 5 has two aspects of complexity; the index is fractional and it is negative. Without further discourse with the student, it would be difficult to address effectively his criticism, which is nonetheless valid.

Student 6 found the diagrams confusing but this does not seem have impaired his confidence. It appears that students can be selectively receptive to different parts of a presentation.

5.3.3 Topic most effectively presented: Rearranging formulae

Question 4 asks "Was there any topic where the presentation was particularly helpful to understanding?"

Rearranging formulae was selected by more students (7 in number) than any other topic, as shown in Table 5.5.

Topic	No of students
Rearranging formulae	7
Graphs	6
Fractions	5
Negative numbers	5
Expanding brackets	5
Linear equations	5
Equations from formulae	5
Trigonometry	5
Forming equations	4
Indices	4

Table 5.5: Presentations which were particularly helpful to understanding

The reasons given for selecting topics are shown in Table 5.6. Students who selected the topic, Rearranging Formulae, are marked with an asterisk.

Student 6 is the only student to select only one topic. His comment, therefore, must relate specifically to the topic, rearranging formulae.

		Tutor related	Electronic resources related	Step-by-step/simplification
*1	tutors demonstration on interactive board	1	1	
3	I found the revision pack book very clear. Also the on screen projector was useful especially for trigonometry.		1	
*5	Good communication with the tutor.	1		
*6	The explanation on how to do it one step at a time	1		1
*8	with a teacher explaining and helping you, it makes things simpler.	1		
*9	All the topics was explained properly and taught well. The topic Fractions I feel was rushed a bit but other wise the computer & the projector made it a lot easier to understand what the teacher was trying to explain.	1	1	
10	I liked the kangaroo it really helped me get my head around negative multiplication.		1	
*11	Work on the Graphics calculator was very useful. Perhaps a little more time explaining the functions would be appreciated as the T84 is used extensively on the pathways course.			
*13	The use of IT was particularly helpful as it easily simplified each process. I fully understood negative numbers thanks to Mr Kangaroo!		1	1
14	Using the board and the CDs on the computers helped to go through everything step by step which helped increase my confidence in the topics by giving an example then using interactive tests.		1	1
Totals		5	6	3

Table 5.6: What made presentations particularly effective.

Of the ten responses giving reasons why presentations were considered to be particularly helpful, five mention aspects specifically relating to the activities of the tutor. Others mention aspects which imply inclusion of activities of the

tutor, e.g. student 13 – the **use** of IT. Six students make specific reference to the use of electronic resources.

5.4 Summary

With the exception of one student (ID 12) who left the summer school, all students appear to have engaged with the subject to at least some degree.

Of the 15 students who started on the summer school, nine expressed better understanding, or increased confidence, or both, as a benefit of the summer school (IDs 1, 2, 3, 4, 6, 7, 9, 14 and 15). A further four expressed consolidation or refreshing of mathematical skills as a benefit (IDs 8, 10, 11 and 13).

For the remaining student (ID 5) a specific benefit was not identified, but there is evidence of engagement with the subject.

It is therefore concluded that a significant degree of constructive alignment was achieved.

Twelve students have provided evidence of identifiable benefits from the use of computer-based materials (IDs 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 13 and 14).

One student, ID 5, has acknowledged their usefulness. Although there is insufficient evidence to conclude that Student ID 15 benefited from their use, he does not appear to have been disadvantaged by it.

In this study, there is no evidence that the use of computer-based material in the classroom was detrimental to the achievement of constructive alignment. No student has made a pejorative observation about the use of computer-based material, or deprecated its use.

It is therefore concluded that, in this study, the use of computer-based presentation material contributed to the achievement of a significant degree of constructive alignment.

Pedagogic aspects of this analysis are discussed in Chapter 6.

Chapter 6: A discussion of results

6.1 Introduction

Apart from one student (ID 12) who left the summer school early, the feedback from students indicates that they engaged with the subject and gained something from the summer school. The results show that a significant degree of constructive alignment was achieved.

It is not suggested that similar results could not have been achieved without the use of computer-based materials. Their use, however, was integral to the delivery method adopted and the results are successful. It cannot be claimed that their use was essential to achieve the outcomes which were achieved. Nor is it suggested that their use, by itself, could be sufficient to achieve these outcomes. The conclusion is that the use of computer-based presentation materials can play a significant role in an effective pedagogy.

The computer-based material was used extensively for whole-class teaching. Individual support, however, was also provided. The contribution from each of these aspects has to be complementary, or aligned.

My thesis is that computer based presentation materials provide an additional medium, making the subject of interest to a wider audience.

A relevant question for teachers is, 'Am I trying to help students to construct their own knowledge and understanding, or am I trying to give them my knowledge and understanding?' Presentations are an extension of the presenter and ideally are customised to the audience. The medium through

which the presenter communicates can enhance or diminish the communication.

Media types include spoken, written, pictorial, animated, interactive.

Animation and interactivity can be provided by computer-based material, which need not displace existing media. Computer-based presentation is an effective medium with its own characteristics. It is a creative tool for teachers to express themselves visually. As with any medium, the teacher needs to feel comfortable with it. The principle of Biggs's (2003, p20-22) constructive alignment is harmony among all elements of the learning situation.

6.2 Pedagogic aspects

6.2.1 Presentation

Presentation material does not replace the presenter. This point is made by Mayes and de Freitas (2005, p15) and Webb (2005, p731). Electronic presentation was used extensively on the summer school in place of a conventional white board. The main advantage from the teacher's point of view was the ease of presentation. Petty (1998, p324) upholds the benefits of overhead projection. The use of electronic projection enhances these benefits. The use of prepared projection material implies that it is unnecessary for the audience to see the teacher writing the material onto a board. This is not a principle to be applied generally, but it makes a sensible criterion for deciding whether to use prepared projection material or to use a conventional whiteboard. An audience generally can read faster than a presenter can write. Text, mathematical expressions, equations and diagrams can be displayed immediately and the overall visual result of size, colour and layout is precisely

as planned. This represents a saving in time during a presentation. The saving in time, however, is less important than the removal of potential distraction. If it is not necessary for the audience to see the act of writing onto the board, then this is a distraction for both the audience and the presenter. Cleaning of the board is certainly an activity which does not contribute to a presentation. While an experienced teacher may take into account the time required for writing onto the board and cleaning it, this is still a constraint on the lesson plan and such activity can inhibit the flow of a presentation. If periods of reflection or other activity are desirable within a presentation then these can be appropriately planned and their timing need not be dictated by the need to clean the board.

This benefit was acknowledged by student 9; *"...with the software you saved a lot of time. So, more time-efficient"* (transcript lines 609-610);

"It was all laid out for you. You didn't have the teacher moving from one side of the board to the other trying to explain something. It was there; all done for you and step by step what you wanted; you could always go back and could go forward" (transcript lines 629-632).

6.2.2 Step-by-step construction of processes

Four students (IDs 6, 8, 9 and 13) identified the step-by-step simplification of processes as being beneficial. The use of computer-based material to achieve this is a natural development of the techniques of overlaying and combining acetate sheets advocated by Petty (1998, p324). Computer-based material, I would contend, requires less effort of the presenter at the time of presentation and gives a clearer illustration to the audience than acetate sheets. Standard

computer software facilitates the production of high quality text and diagrams, even for people with limited drawing skills. Rather than print from the computer onto acetates, it seems logical to project directly from the computer to the screen, thus reducing the preparation time and the material required.

6.2.3 Differentiated pedagogy

From Table 4.1 in Chapter 4 it can be seen that the range of mathematics qualifications of the summer school students is wide; 3 students had GCSE/O-Level grade B; 3 students had GCSE grade C; 1 student had GCSE grade D; 3 students had a CSE or GCSE in a maths related subject and the remaining 5 disclosed no formal mathematics qualification at all.

There is striking contrast in the profiles of student 11 and student 14. The former was male, aged 44, had been good at maths at school, held a grade C GCSE in mathematics and a Higher National Certificate, and had confidence in his abilities. The latter was female, aged 18, had no formal qualification in mathematics, and initially had little confidence in her mathematical ability.

Student 14 declined to take part in an interview but completed an end of course feedback questionnaire. Her test score for the final test was significantly higher than for the daily topic tests, indicating an improvement in mathematical skills. Her feedback questionnaire indicates a significant change of attitude towards mathematics. Before the course she believed that she could not do maths and now she believes that she can.

It is possible that the transformation in student 14 could have occurred on a different course, in a different place with a different tutor using different methods.

The point of this thesis is that computer-based presentation material was an integral part of the pedagogy used on the summer school and therefore it made a contribution to the engagement in mathematics of students with a range of different profiles.

The principle of differentiated pedagogy can be seen in the software used to illustrate transposition of equations. Figure 6.1 shows the final three slides of a presentation illustrating the transposition of the equation, $p = 4y - 2$, to make y the subject. For some students it would be sufficient to show only three lines of working,

$$\begin{aligned}p &= 4y - 2 \\p + 2 &= 4y \\ \frac{p + 2}{4} &= y\end{aligned}$$

and to provide a verbal explanation of the progression from one line to the next. For other students the inclusion of the intervening line,

$p + 2 = 4y - 2 + 2$, showing explicitly the operation would be helpful; for

others it might be essential. This intervening line serves not only as a stepping-stone to the next line. It emphasises the concept of balance between both sides of an equation; operations applied to one side must also be applied to the other. In the Introduction, attention was drawn to experience that difficulties could arise from misuse of the dubious concept of moving terms

from one side of an equation to the other. Absence of the intervening lines tends to suggest this process, 'change the side – change the sign'. The use of projection technology allows intervening steps to be included with minimal, if any, disadvantage to those for whom they might not be absolutely necessary. A similar illustration is shown in Figure 3.2 for solving equations. The purpose is to provide adaptable access to the same destination, just as a steady incline, or ramp, provides access for wheelchair users but does not prohibit walkers. For some students the intermediate steps in Figure 6.1 need not be explicit: they do not need to see them in writing. Seeing these steps in writing, however, is not a disadvantage to such students. Promptness of presentation ensures that for such students a minimum amount of time is spent on activity which is unnecessary for them, but which is helpful for others. If a conventional whiteboard were used, then writing the intervening lines would certainly take more time, which is a potential source of distraction for any student who does see them as essential, and possibly also for others. Petty's (Petty 1998, p337) criterion for making use of computers is whether or not they do something that needs doing. Widening participation in Higher Education needs differentiated pedagogy and the use of computer-based presentation material can facilitate the use of differentiated pedagogy.

$p = 4y - 2$ $p + 2 = 4y$ $\frac{p + 2}{4} = \frac{4y}{4}$	$y = ?$ +2 both sides simplify -4 both sides
--	---

(a)

$p = 4y - 2$ $p + 2 = 4y$ $\frac{p + 2}{4} = \frac{4y}{4}$	$y = ?$ +2 both sides simplify -4 both sides simplify
--	---

(b)

$p = 4y - 2$ $p + 2 = 4y$ $\frac{p + 2}{4} = y$	$y = ?$ +2 both sides simplify -4 both sides simplify
---	---

(c)

Figure 6.1: Differentiated pedagogy

6.2.4 Design of computer based learning materials

With overlaid acetate sheets there are practical limitations on what can be achieved. If the desired effect is excessively complex then the manipulations of the acetate sheets can become a distraction for the audience. A principle that emerges here is that during a presentation the audience need to see the subject matter, but not the mechanism of presentation. Criticism from student10 (transcript lines 667-672) arises from the fact that he was distracted by information on the screen that was needed by the presenter but which was not necessary for the audience. The topic was indices and this piece of software has now been redesigned.

Table 5.6 lists the reasons given by students why they considered sessions or presentations to be helpful. Of the six students (IDs 1, 3, 9, 10, 13 and 14) who specifically mentioned electronic resources, five (IDs 1, 9, 10, 13 and 14) implied that the helpfulness was related to how it was used by the tutor. Three other students (IDs 5, 6 and 8) specifically mention activities of the tutor. This supports Laurillard's (1993 p215/6) view that the success of new-technology materials depends largely on how they are integrated into a course and that this must be taken into account when the materials are designed.

Three students (IDs 6, 13 and 14) identified the aspect of *step-by-step* simplification. It is possible that others may have benefited from this aspect but they did not specifically allude to it in their responses. Nowhere in the data is there any pejorative reference to this aspect. Other students (IDs 3, 5, 8, 9, 10) used phrases that implied the enabling of understanding: "very clear",

"Good communication", "explaining...simpler", "explained properly" and "helped me get my head around".

All of the computer-based presentation material used on the summer school had been created by the tutor delivering the course. In designing the material it was intended that students, having seen the material used during a lesson, would also be able to use it by themselves for revision. Therefore, the material had to be simple to use, requiring no more than elementary computer skills. Forster (2006, p157) describes the considerable amount of technical instruction and direction provided by a teacher during a lesson where graphics calculators were used to good effect to illustrate the principles of linear regression of scatter graphs. The teacher also used material (Java applets) from the internet which facilitated dynamic manipulation of two scatter graphs. The output from one calculator and the applet graphs were projected onto a screen. The materials used fall into two distinct categories. The dynamic graphs (Java applets) are primarily illustrative, teaching/learning resources, although it is conceivable that they may also be used as statistical tools in a limited context. The graphics calculator is primarily a tool for mathematicians, but can also be used for illustration and teaching. Webb (2005, p707) writes of 'affordances' of technology. In very simple terms an affordance is an opportunity for learning. The usefulness of an affordance is dependent on two factors, its visibility and the level of proficiency needed to pursue the affordance: the student has to have awareness of the opportunity and ability to make use it.

Increasing the number of affordances necessitates the implementation of mechanisms for accessing them. In computer software the drop-down menu

has become ubiquitous. On keyboards for computers and calculators different keys or combinations of keys are used to facilitate different functions. Forster (2006, p157) indicates that the complexity of a resource, in this case a graphics calculator, can be a barrier to learning: the affordance is not highly visible and the students need detailed instruction on how to make use of the affordance. O' Reilly (2005, p75) describes a similar experience when a group of trainee teachers used spreadsheets to teach mathematics. Both studies (O'Reilly 2005; Forster 2006) also report benefits from the use respectively of graphics calculators and spreadsheets and do not suggest that they are unsuitable as classroom resources for teaching and learning. From these studies (O'Reilly 2005; Forster 2006), however, it seems likely that the students could have had difficulty in making use of these resources by themselves immediately subsequent to the lesson, had they been expected to do so.

What has been attempted in the summer school is to use material with affordances that are highly visible and require minimal proficiency. This necessarily reduces the range of affordances offered by any one piece of material.

Clearly there is a need for further research and development of computer-based presentation material which can provide affordances appropriate for the increasing proportion of the population now entering Higher Education.

6.3 Key findings

The key finding of this study is that the use of computer-based presentation materials can make a recognisable contribution in effectively engaging in

mathematics a group of adults of widely differing levels of confidence and prior mathematical attainment. In the terminology of Biggs (2003, p20-22) the use of computer-based presentation materials can make a contribution towards constructive alignment.

The main criterion in deciding whether to project prepared material or to write onto a whiteboard is whether or not there is a benefit for the audience in seeing a person writing onto a board.

In Chapter 3, three categories of presentation material are described which have respectively increasing potential for providing affordances for learning, basic, illustrated and interactive.

A vital aspect of the material used appears to be the facilitation of differentiated pedagogy. Some students on the summer school identified the step-by-step illustration as being particularly beneficial. Those who did not identify it as such did not indicate any aversion for this level of simplification.

6.4 Summary

In his concept of constructive alignment Biggs (2003, p20-22) has recognised the need for harmony between tutors, students and the learning environment. Petty (1998) has outlined teaching methods for appealing to a wider audience. Computer based presentation material provides a development in the media available to tutors to assist them to reach a wider audience. The success of this media depends very much on how it is implemented. This study has shown that it is possible to make use of computer-based presentation material to the benefit of some, without detriment to others.

This study affirms the following pedagogic principles with respect to computer-based presentation materials.

- The material does not replace the presenter. How it is used is at least as important as the material itself.
- Established principles, such as those described by Petty (1998) for creating effective presentation materials, are relevant regardless of the medium.
 - Make sure the design:
 - uses a minimum of words
 - is uncluttered
 - is eye-catching
 - Highlight important words
 - Too many colours on a sheet are confusing, unless there is a clear purpose for each colour. (Petty 1998, p323)
- Presentation mechanisms should not distract from the information being presented. The design of computer-based material should seek to minimise the visibility and/or intrusion of control mechanisms used by the presenter.
- The presenter must be comfortable in using the material and the medium. If this condition is satisfied then projection of computer-based materials can make a valuable contribution to pedagogy.

- Computer-based presentation materials can readily facilitate step-by-step simplification of processes. It can make it possible to illustrate a topic to a degree necessary to include all members of an audience without disadvantage to those who might be satisfied with a lesser degree of elucidation. It thus facilitates differentiated pedagogy.
- Criteria for choosing between using a conventional whiteboard and the electronic projection include

- Is it necessary for the audience to see a person writing and/or drawing on the board?

If it is not necessary then electronic projection offers the benefit of eliminating an unnecessary and potentially distracting activity.

- Is it known in advance what words, diagrams and/or examples will be displayed?

The need to respond to questions from the audience might preclude the prior preparation of some material. A conventional whiteboard facilitates illustration arising from interaction with the audience. It is, however, possible for this immediacy to be achieved through electronic projection. Some of the presentation software listed in Appendix H provides a degree of interactivity that allows spontaneous illustration of examples conceived during a presentation. An example is described in section 3.3.3.

Chapter 7: Concluding observations

7.1 The initial problem

The mathematics problem highlighted by Savage et al (2000, piii) suggests an uncertain future for mathematics as part of the curriculum. The problem, however, is complex. While some aspects of the problem may be peculiar to mathematics, there are aspects that affect education generally. In the second half of the 20th century the proportion of the population entering higher education has increased dramatically as shown in figure 2.1. Well-intentioned changes to the delivery and assessment of primary and secondary education have led to calls for a period of stability (Burghes *et al.* 2004, p642). If mathematics has particular problems then these problems have been enveloped in the wider problem of making higher education accessible to a greater proportion of the population.

7.2 A wider perspective

Selection for entry to Higher Education is ostensibly by academic ability. It is realistic that social and cultural factors may also influence perceptions of eligibility to enter Higher Education. This is recognised in the government initiative, Widening Participation (DfES 2003b, p2), which seeks to encourage a wider section of the population to consider entering Higher Education. Thus, entry requirements for Higher Education may be seen as a filter comprising stipulated (academic) criteria and perceived (social and cultural) criteria, including perceptions about the process of learning.

At the start of the 20th century approximately 25 thousand people passed through the filter for entry to Higher Education (Robbins 1963). By the middle of the century the figure had risen steadily to 122 thousand, an average increase of around 2 thousand per year during the first half of the century.

To achieve growth in any institution, either there needs to be an increase in the number of applicants whose characteristics allow them to pass through the selection filter, or the filter can be changed, in which case the institution needs to modify its activities to accommodate the different characteristics of the people it has admitted.

It is conceivable that, in the first half of the 20th century, institutions of Higher Education could absorb and assimilate the steadily growing number of students passing through the selection filter: the filter may have opened a little but essentially the increased number could have adapted and conformed to existing practices and cultures within Higher Education without greatly impacting on the identity of Higher Education.

By the end of the century the number of students in Higher Education had reached more than 2 million, an average growth rate of approximately 38 thousand per year during the second half of the century.

By recommending dramatic growth in the proportion of the population entering Higher Education, the Robbins (1963) report effectively changed the filter for entry into Higher Education. Savage et al (2000, piii) cite, "an increasing inhomogeneity in the mathematical attainments and knowledge", and show a graph of declining performance of the student intake at York University from 1979 to 1999 (Savage et al. 2000, p26).

7.3 Implications for teachers

As the educational aspirations of a wider section of the population are raised, educational establishments must accommodate a wider range of students. Pedagogy that may have been adequate for a small selected proportion of the population may not be adequate for the target of 50% of the population (DfES 2003a, p57). There has to be what Biggs (2003, p20-22) calls constructive alignment; harmony among the teacher, the students and the learning environment. Cockcroft (1982, p71) held that teaching needed to be related to the abilities and experience of both teachers and pupils. Clearly, teachers need to be engaged in the development of pedagogies to meet the aspirations of students. Smith (2004, p160) indicates a belief that ICT can be used to enhance the teaching of mathematics.

7.4 The use of electronic presentation materials

As a medium, electronic presentation provides potential for versatile pedagogy. Despite their very different profiles, described in chapter 5, all students who completed the summer school considered that they had benefited from it.

While enthusiasm for electronic presentation was greater in some students than in others, no student on the summer school considered that its use had been detrimental to their learning.

The study has shown that electronic presentation materials, embedded within pedagogy, can assist in the achievement of constructive alignment with students of very different backgrounds within the same group. The study found no evidence that its use had impeded the achievement of constructive

alignment for any of the students. It is, however, imperative that the teacher feels comfortable in using the material, or in Biggs's terminology, there is constructive alignment.

Principles of effective pedagogy are known (Bloom 1956; Piaget 1971; Laurillard 1997; Petty 1998; Biggs 2003; Burghes *et al.* 2004). These principles are applicable to electronic projection as much as to other presentation media.

In order to realise the pedagogic potential of electronic presentation materials continuing staff development in their use and further research into their design are necessary.

7.5 Questions for further research

The materials used do not represent final, fully developed products. The software for illustrating indices has been comprehensively modified in the light of feedback from the summer school.

Useful further research could identify differences and similarities of perception gained by students attending the same presentation. It would be useful to identify characteristics of mathematics presentation materials which are conducive to assimilation of mathematics by different students.

The aim of such research would be to identify ways of presenting mathematics topics to make them accessible to as wide an audience as possible without any member of the audience perceiving the presentations to be insufficiently fulfilling.

References

- Abrams, J. P. 2001. *Teaching mathematical modeling and the skills of representation*. Virginia. 269-282
- Arganbright, D. E. 1993. Innovations in mathematics through spreadsheets. *Informatics and Changes in Learning*, **A-34**, 125-147.
- BECTa 2004. *Ict and e-learning in further education, a report to the learning and skills council*. British Educational Communications and Technology Agency, Coventry.
- Berry, C., Bryden, P., Cowey, D. and Faulkner, D. 2004. *Mathematics intermediate*. Hodder & Stoughton, Abingdon.
- Berry, J. and Sharp, J. 1999. Developing student-centred learning in mathematics through co-operation, reflection and discussion. *Teaching in Higher Education*, **4**, 27-37.
- Biggs, J. *Teaching*. Maidenhead.
- Biggs, J. 2003. *Teaching for quality learning at university*. The Society for Research into Higher Education & Open University Press.
- Bloom, B. S. 1956. *Taxonomy of educational objectives : The classification of educational goals*. Longman, London.
- Burghes, D. and Hindle, M. 2004. Response to key issues raised in the post-14 mathematics inquiry. *International Journal of Mathematical Education in Science and Technology*, **35**, 633-660.
- Chinn, S. J. and Ashcroft, J. R. 1998. *Mathematics for dyslexics: A teaching handbook*. Wiley, Chichester.
- Cockcroft, W. H. 1982. *Mathematics counts*. Her Majesty's Stationery Office, London.
- Cohen, L., Manion, L. and Morrison, K. 2001. *Research methods in education*. RoutledgeFalmer, London.

Cox, M. and Webb, M. 2004. A review of pedagogy related to information and communications technology. *Technology, Pedagogy and Education*, **13**, 235-286.

Daniel, M. 2003. From crass to classics in one sword stroke. *Western Morning News*. Plymouth. (Issue), 14 Feb 2003, 10.

DfEE 1999. *The National Curriculum for England: Mathematics*. Department for Education and Employment and Qualifications (DfEE) and Curriculum Authority (QCA), London.

DfES. 2001. Students in higher education: By type of course and gender: Social trends 32.
<http://www.statistics.gov.uk/STATBASE/ssdataset.asp?vlnk=5027>. Accessed July 2006

DfES 2002. *Computers for teachers*. British Educational Communications and Technology Agency, London.

DfES 2003a. *The future of higher education*.

DfES 2003b. *Widening participation in higher education*. UK Government.

Dickens, C. 1994 Edition. *Hard times*. Penguin, London. (First published in 1854 in *Household Words*)

Dossey, J. A. 1992. The nature of mathematics: Its role and its influence. *Handbook of Research on Mathematics Teaching and Learning* Ed Grouws D A, 39-48.

Egerton, P. 2001. From the gold standard to silver service. *The newsletter of the LTSN Maths Stats & OR Network*, **1**, 21-23.

Ernest, P. 1995. *The philosophy of mathematics education*. The Falmer Press, Basingstoke.

Evans, K., Gordon, K., Senior, T. and Speed, B. 2003. *Maths frameworking — year 8 pupil book 1*. Collins Educational, London.

Forster, P. A. 2006. Assessing technology-based approaches for teaching and learning mathematics. *International Journal of Mathematical Education in Science and Technology*, **37**, 145-165.

Goos, M., Galbraith, P., Renshaw, P. and Geiger, V. 2000. Reshaping teacher and student roles in technology-enriched classrooms. *Mathematics Education Research Journal*, **12**, 303-320.

Graham, T. 2002. AS mathematics: The result of a survey of schools and colleges. *Teaching Mathematics and its Applications*, **21**, 11-28.

Hamilton, E. and Cairns, H. 1973. *Plato complete*. Princeton University Press, Princeton.

Hawley, R. 2003. Let's get creative. *The IEE Review*, **49**, 62.

Heid, M. K. 2002. How theories about the learning and knowing of mathematics can inform the use of cas in school mathematics: One perspective. *The International Journal of Computer Algebra in Mathematics Education*, **9**, 95-111.

Honey, P. 1992. *The manual of learning styles*. Peter Honey, 1992.

Kaput, J. J. 1992. Technology and mathematics education. *Handbook of Research on Mathematics Teaching and Learning* Ed Grouws D A, 515 - 556.

Keats, D. M. 2000. *Interviewing: A practical guide for students and professionals*. Open University Press, Buckingham.

Kent, P. 2002. Should we reassess the role of mathematics in engineering education. *LTSN Maths Stats & OR Network: Maths CAA Series*,

Kissane, B. 2003. *A model for professional development for graphics calculator use*. The Decidable and the Undecidable in Mathematics Education. Czech Republic. September 2003.

Laurillard, D. 1997. *Rethinking university teaching*. Routledge, London.

Mayes, T. and de Freitas, S. 2005. Review of e-learning theories, frameworks and models. <http://www.elearning.ac.uk/resources/modelsdeskreview/view>. Accessed July 2006

McCormick, R. and Scrimshaw, P. 2001. *E851 information and communications technology, knowledge and pedagogy*. The Open University, Milton Keynes.

MSOR. 2005. <http://mathstore.ac.uk/aboutus/mission.shtml>. Accessed July 2006

Nickson, M. 2000. *Teaching for quality learning at university*. Cassell, London.

Norton, S., McRobbie, C. J. and Cooper, T. J. 2000. Exploring secondary mathematics teachers' reasons for not using computers in their teaching: Five case studies. *Journal of Research on Computing in Education*, **33**, 87.

ONS. 2001. Population: Age, sex and legal marital status. <http://www.statistics.gov.uk/StatBase/Expodata/Spreadsheets/D9111.xls>. Accessed July 2006

O'Reilly, D. 2005. Student teachers' experiences of using spreadsheets. *Proceedings of the British Society for Research into Learning Mathematics*, **25**, 73-78.

Petty, G. 1998. *Teaching today*. Stanley Thornes, Cheltenham.

Piaget, J. 1971. *Science of education and the psychology of the child*. Longman, London.

Picker, S. H. 2000. *An investigation of lower secondary pupils' images of mathematics and mathematicians*. Doctoral, University of Plymouth.

Pritcher, J. 1985. *Francis bacon the essays*. Penguin, London.

Pyle, I. 2001. Mathematics in schools. *Computing and Control Engineering Journal*, **12**, 201-240.

Robbins 1963. *Higher education*. United Kingdom Government, London. 1-335.

Savage, M., Kitchen, A., Sutherland, R. and Porkess, R. 2000. *Measuring the mathematics problem*. The Engineering Council, London. 1-27.

Silverman, D. 2002. *Interpreting qualitative data*. Sage Publications, London.

Skemp, R. R. 1976. Relational understanding and instrumental understanding. *Mathematics Teaching*, **77**, 22-26.

Smith, A. 2004. *Making mathematics count*. The Stationery Office Ltd., London.

Tariq, V. 2005. Using a contextual e-learning approach to teaching maths. *Bioscience Bulletin*, **15**, 4-5.

Tomlinson, M. 2004. *14-19 curriculum and qualifications reform*. HM Government, London. 1-116.

University of Plymouth. 2005. Foundation pathways in technology.
<http://www.plymouth.ac.uk/files/extranet/docs/TEC/Foundation%20Pathways%20Bro.pdf>. Accessed July 2006

University of Plymouth. 2006. Postgraduate Certificate in Learning and Teaching in Higher Education (LTHE).
<http://www.plymouth.ac.uk/pages/view.asp?page=8086>. Accessed September 2006

Watson, A. and De Geest, E. 2005. Principled teaching for deep progress: Improving mathematical learning beyond methods and materials. *Educational Studies In Mathematics*, **58**, 209-234.

Webb, M. E. 2005. Affordances of ict in science learning: Implications for an integrated pedagogy. *International Journal of Science Education*, **27**, 705-735.

White, K. A. J. 2002. Setting the scene. *The newsletter of the LTSN Maths, Stats & OR Network*, **2**, 8-9.

Appendices

Appendix A: Application for Ethical Approval

UNIVERSITY OF PLYMOUTH
FACULTY OF TECHNOLOGY



Faculty of Technology Ethics Committee (FTEC)

APPLICATION FOR ETHICAL APPROVAL OF RESEARCH OR OTHER PROJECTS INVOLVING HUMAN PARTICIPANTS

In completing this form reference should be made to Faculty Procedures and the University of Plymouth document Ethical Principles for Research Involving Human Participants

Title of Research:

1. Nature of Approval Sought (please tick relevant box)

RESEARCH

☒

OTHER PROJECT:

☐

Please tick which category:

Funded Research Project

☐

MPhil/PhD Project

☒

Other Project (please specify below):

☐

2. Name of Principal Investigator or Project Leader or Director of Studies*:

(Name of Director of Studies is required where Principal Investigator is a postgraduate student)

Ted Graham

Contact Details**: Room 114, Mathematics and Statistics, 2 Kirkby Place.

e.graham@plymouth.ac.uk

**Principal Investigators, Directors of Studies and Project Leaders are responsible for ensuring that all staff employed on research or projects (including research assistants, technicians and clerical staff) act in accordance with the University's ethical principles in the design and conduct of the research or project described in this proposal and any conditions attached to its approval.*

****Please indicate department of each named individual, including collaborators external to the Faculty.**

3. Funding Body and Duration of Project/Programme with Dates:

June 2002 to June 2006

4. Aims and Objectives of Research Project/Programme:

To identify how the incorporation of technology in teaching methods might assist or impede the use of higher cognitive procedures within a particular group of students.

5. Brief Description of Research Methods and Procedures:

Please specify subject populations and recruitment method. Please indicate also any ethically sensitive aspects of the methods. Continue on an attached sheet if required.

Subject population: Students attending a two-week summer school in Basic Mathematics as preparation for entering the Foundation Pathways course.

Data will be collected through the following media.

Initial questionnaire (Attached).

Interviews. (Attached + briefing)

Course feedback questionnaire (Attached).

Results from assessment which form part of the course.

All students will be invited to participate. Please see attached invitation.

6. Ethical Protocol:

Please indicate how you will ensure this research conforms with each clause of the University of Plymouth's Principles for Research Involving Human Participants. Please include a statement which addresses each of the ethical principles set out below.

(a) Informed Consent:

Invitations to participate will ask for participants' written consent to use data relating to them.

(b) Openness and Honesty:

The purpose of the research will be explained on the invitation to participate.

Invitees will be able to ask questions of the researcher before agreeing to participate. There is no reason for any information to be withheld from participants.

Throughout the period of data collection participants will have the opportunity to ask questions about the project and to withdraw if they wish.

Note that deception is permissible only where it can be shown that all three conditions specified in Section 2 of the University of Plymouth's Ethical Principles have been made in full. Proposers are required to provide a detailed justification and to supply the names of two independent assessors whom the Sub-Committee can approach for advice.

(c) Right to Withdraw:

Immediately before any interview is conducted or any questionnaire issued, participant will be reminded of their right to withdraw.

(d) Protection From Harm:

The project will not introduce any physical hazard.

Interviews will be conducted with sensitivity.

(e) Debriefing:

An account of the purpose of the study and its procedures will be provided at the commencement of the project.

(f) Confidentiality:

Transcriptions of interviews will be encoded so that no written record of the participant's name and data exist side by side.

Data entered into a computer will be encoded; names will not be included in data records.

(g) Professional Bodies Whose Ethical Policies Apply to this Research or Project:

No other Professional body is involved.

7. Declaration:

To the best of our knowledge and belief, this research or Project conforms to the ethical principles laid down by the University of Plymouth and by the professional body specified in 6 (g).

	Name	Email (s)	Date
Principal Investigator:	Brian Watson	bwatson@plymouth.ac.uk	15/7/2005
Other Project Leader:			
Director of Studies (where Principal Investigator is a postgraduate student):	Ted Graham	e.graham@plymouth.ac.uk	15/7/2005

Completed Forms should be forwarded BY EMAIL to the Secretary. These will be forwarded to members of the Committee. Responses will normally take two weeks to process so please ensure applications are submitted in sufficient time for approval to be considered before the start of the proposed research or project.

You will be notified by the Ethics Committee once your application has been considered and approved.

Appendix B: Invitation to participate

Invitation to participate in a mathematics research project

As a student on the Foundation Pathways Summer School you are invited to participate in a research project to investigate the use of computer based material for teaching mathematics.

An outline of the project is given on page 2.

You are not obliged to take part in the project, but your assistance will be very much appreciated and may influence educational developments within the University of Plymouth.

If you are willing to participate please sign the consent below.

I consent to data relating to me being used anonymously in this research project, entitled 'An investigation into the use of computer based material for teaching mathematics'.

Name:	Signature:	Date
-------	------------	------

If, at any time during the Summer School, you inform us that you do not wish to participate, then this consent form will be returned to you and data relating to you will not be used in the project.

Main researcher

Brian Watson

Room 101

Centre for Teaching Mathematics

3 Kirkby Place

University of Plymouth

Email: bwatson@plymouth.ac.uk

Tel. 01752 232776

Supervisor:

Dr E Graham

Room 114

Centre for Teaching Mathematics

3 Kirkby Place

University of Plymouth

Email: egraham@plymouth.ac.uk

Tel. 01752 232773

Outline of research project

Project title	An investigation into the use of computer based material for teaching mathematics.
Purpose	<p>The role and use of technology within education is expanding.</p> <p>An area of major interest and importance to the Centre for Teaching Mathematics is how technology can be used effectively to improve conceptual understanding of mathematics.</p> <p>This research will assist in identifying how the incorporation of technology in teaching methods might assist or impede students' understanding of mathematics.</p> <p>This project forms an element of Brian Watson's studies for the award of Master of Philosophy.</p>
Participants	<p>All students on the Foundation Pathways Summer School will be invited to participate.</p> <p>Participants will be asked</p> <p>to complete a questionnaire at the start of the course,</p> <p>to be interviewed to find out their views on mathematics and aspects of the course. Interviews will be tape recorded and then transcribed into a text format.</p> <p>to complete a questionnaire at the end of the course.</p> <p>Names will not be included in any analysis of the data. Participants are assured of confidentiality and anonymity in any analysis or processing of the data.</p> <p>Participation or non-participation in this research project will not be used to assess any student's achievement on the Summer School.</p>
Duration	<p>Data will be collected during the Foundation Pathways Summer School, held in the first two weeks of September 2005.</p> <p>It is expected that analysis of the data will be completed by 1st January 2006.</p>

Appendix C: Interview Briefing

Interview Briefing

Thank you for agreeing to take part in this study.

The purpose of this study is to find out whether you found the computer based material helped you understand Maths.

I am not looking at your Maths ability, and will not be assessing your Maths, rather I just need to find your opinions about how you felt about the computer based material helped you understand Maths.

As I will be asking you some questions about your opinions, there is no wrong or right answer (as you normally find in Maths questions), rather it is just your opinions which we would like to find out about.

To help me collect your opinions I will be tape recording your answers. The answers will then be transcribed into a text format.

To ensure that all your answers are confidential no one else will be able to hear the tape recording. The transcribed text will only be identified by student A, student B etc. Your name will not appear next the text. None of your answers will be kept on your student record. The tape will be erased once we have transcribed your answers.

You do not have to answer all the questions, and if you would prefer not to answer any particular question, just say so and we will move on to the next question.

At the end of the questions, if you feel that you do not want your answers to be used in our study just say so and we will erase the tape. So even though you have consented to take part in this study you can withdraw at any time.

Are you happy for us proceed with the questions to tape record your answers

Appendix D: Initial survey

Feelings about mathematics

The purpose of this questionnaire is to find out how you feel about mathematics. It forms part of a research project investigating the use of computer based material for teaching mathematics.

You are not obliged to complete the questionnaire, but your assistance will be very much appreciated and may influence educational developments within the University of Plymouth

Your response to this questionnaire will not be used to assess your performance in your studies.

Name:

Your name is required on this front sheet in order to link responses to this questionnaire with other responses which you may provide later.

Names will not be included in any analysis of the data. Individuals are assured of confidentiality and anonymity in any analysis or processing of the data.

Brian Watson
Centre for Teaching Mathematics
3 Kirkby Place
University of Plymouth
Email: bwatson@plymouth.ac.uk

Mathematics at school

For questions 1 to 4 please tick or cross the statement which is most appropriate for you.

1. Please tick one box

At school I wasn't very good at maths, probably in the lower half of the class.	
At school I was OK at maths, probably about the middle of the class.	
At school I was good at maths, probably in the top half of the class.	

2. Please tick one box

At school I enjoyed mathematics most of the time.	
At school I enjoyed mathematics sometimes.	
At school I rarely enjoyed mathematics	

3. Please tick one box.

At school I usually liked solving mathematical problems.	
At school I didn't mind solving mathematical problems.	
At school I didn't usually like solving mathematical problems.	

4. Please tick one box.

At school I usually liked questions that asked you to do something specific, (for example, "Calculate the number of ...")	
At school I didn't mind questions that ask you to do something specific.	
At school I didn't usually like questions that ask you to do something specific.	

Ideas about maths

For questions 5 to 7 please tick one box to show whether you agree with the statement.

5. You don't need to understand maths as long as you know the rules or the relevant formula.

I agree	
I'm not sure	
I disagree	

6. You need a good memory to be good at maths.

I agree	
I'm not sure	
I disagree	

7. You need to have a good teacher to be good at maths.

I agree	
I'm not sure	
I disagree	

Experiences

8. Can you think of a particular experience which made you like maths?

Yes	
No	

9. Can you think of a particular experience which made you dislike maths?

Yes	
No	

The summer school

10. What is your intended subject area on completion of the Foundation Pathways in Technology course?

School of Computing, Communications and Electronics	
School of Mathematics and Statistics	
School of Engineering	
Don't yet know	

11. What do you expect to gain from this summer school?

Appendix E: Course feedback questionnaire

Course feedback

The purpose of this questionnaire is to find out how appropriate this course has been for you and to identify possible changes we could make to improve the course.

You are not obliged to complete the questionnaire, but your assistance will be very much appreciated and may influence educational developments within the University of Plymouth

Your response to this questionnaire will not be used to assess your performance on the course.

Name:

Your name is required on this front sheet in order to link responses to this questionnaire with other responses which you may have provided as part of a research project investigating the use of computer based material for teaching mathematics.

Names will not be included in any analysis of the data. Individuals are assured of confidentiality and anonymity in any analysis or processing of the data.

Brian Watson
Centre for Teaching Mathematics
3 Kirkby Place
University of Plymouth
Email: bwatson@plymouth.ac.uk

Level of difficulty

1. Was there any topic or part of the course which you found particularly difficult?
If yes, please indicate which topic(s) in the table below.

Topic areas	Tick if particularly difficult
Fractions	
Negative numbers	
Expanding brackets	
Linear equations	
Equations from formulae	
Forming equations	
Rearranging formulae	
Indices	
Graphs	
Trigonometry	

What could have made it easier?

How could you have been helped?

2. Was there anything that you think you could have understood better had it been presented differently?

If yes, please indicate what

Topics/Sessions	What differences would you have preferred?

3. Were there any topics which you found easy?

If yes, please indicate which topic(s) in the table below

Topic areas	Tick if easy	For topics that you have ticked.	
		Had you done this before? Y/N	For you, could the time spent on this have been reduced? Y/N
Fractions			
Negative numbers			
Expanding brackets			
Linear equations			
Equations from formulae			
Forming equations			
Rearranging formulae			
Indices			
Graphs			
Trigonometry			

4. Was there any topic where the presentation was particularly helpful to understanding?

If yes, please indicate which topic(s) in the table below.

Topic areas	Tick if appropriate
Fractions	
Negative numbers	
Expanding brackets	
Linear equations	
Equations from formulae	
Forming equations	
Rearranging formulae	
Indices	
Graphs	
Trigonometry	

What aspect made it helpful?

Content

5. Do you think any of the topic areas should have been omitted?

If yes, please indicate which topic(s) in the table below

Topic areas	Tick if you think topic should have been omitted
Fractions	
Negative numbers	
Expanding brackets	
Linear equations	
Equations from formulae	
Forming equations	
Rearranging formulae	
Indices	
Graphs	
Trigonometry	

If possible please indicate why you think the topic area(s) should have been omitted.

6. Were there any topic areas, which were not included, which you think should have been included?

If yes, please list any topics and if possible, briefly indicate why you think they should have been included.

Delivery

7. Were there any topics or sessions which you consider could have been presented better?

If yes, please indicate which topic(s) in the table below.

Topic areas	Tick if topic could have been presented better.
Fractions	
Negative numbers	
Expanding brackets	
Linear equations	
Equations from formulae	
Forming equations	
Rearranging formulae	
Indices	
Graphs	
Trigonometry	

If possible please indicate why

8. Were there any topics or sessions which were particularly effective for you?
(If yes, please indicate which topic(s) in the table below.

Topic areas	Tick if particularly effective
Fractions	
Negative numbers	
Expanding brackets	
Linear equations	
Equations from formulae	
Forming equations	
Rearranging formulae	
Indices	
Graphs	
Trigonometry	

If possible please indicate what made them particularly effective.

9. Did you find the use of computer based material for presentation by the teacher helpful?

(Please tick one box for each topic)

Topic areas	Yes	No	Don't know/not applicable
Fractions			
Negative numbers			
Expanding brackets			
Linear equations			
Equations from formulae			
Forming equations			
Rearranging formulae			
Indices			
Graphs			
Trigonometry			

Please add any comment which you think appropriate

10. Did you find computer based material used by you helpful?

(Please tick one box for each topic)

Topic areas	Yes	No	Don't know/not applicable
Fractions			
Negative numbers			
Expanding brackets			
Linear equations			
Equations from formulae			
Forming equations			
Rearranging formulae			
Indices			
Graphs			
Trigonometry			

Please add any comment which you think appropriate

11. How much time did the teacher spend speaking/explaining?

(Please Tick one)

Please add comment if appropriate.

Far too much	
A little too much	
About right	
Not enough	
Not nearly enough	

12. How much time did you have to reflect on the subject and practice by doing examples and exercises?

(Please Tick one)

Please add comment if appropriate.

Far too much	
A little too much	
About right	
Not enough	
Not nearly enough	

13. How was the balance between presentation/talk by the teacher and time to do examples and exercises?

(Please Tick one)

Please add comment if appropriate.

Too much teacher presentation	
About right	
Too much time on exercises.	

14. How much individual support did **you** get?

(Please Tick one)

Please add comment if appropriate.

Too much	
About right	
Not enough	

Assessment

15. Did the assessment reflect the content of the course?

(Please tick 'Yes' or 'No')

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

16. Did the assessment reflect the level of the course?

(Please tick 'Yes' or 'No')

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

17. Do you think that the type of assessments were appropriate?

(Please tick 'Yes' or 'No')

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

18. Please indicate any aspect of the assessment which you think could be improved or which you think was not entirely appropriate.

Benefit

19. What benefit do you think you have gained from this course?

Appendix F: Interview prompts

BODMAS

$$(4 + 1) \times 2 - 20 \div (7 - 3) + 4 \times 3 - 8$$

$$5 \times 2 - 20 \div 4 + 4 \times 3 - 8$$

$$10 - 5 + 12 - 8 = 9$$

Order:

() brackets first

$\div \times$ then division & multiplication

$+-$ then addition & subtraction



Fractions

Microsoft Excel - 00 Fraction.xls [Read-Only]

File Edit View Insert Format Tools Data Window Help

100%

Fractions

5 X 10

Set the grid size.
Click on boxes to shade/unshade.

Or click 'New question'

☒ Provide feedback

Show me the answer

Restart

New question

What fraction of the area is shaded?

$\frac{29}{50} = 0.58 = 58\%$

Correct

☐ Demonstration
☐ Quiz

Exit

Draw AutoShapes

Ready

start

NUM

Microsoft Excel - 02 Add.xls [Read-Only]

File Edit View Insert Format Tools Data Window Help

100%

Addition of fractions

Grid size: 5 x 4

Grid size: 5 x 4

$\frac{1}{5} + \frac{1}{4}$

$\frac{4}{20} + \frac{5}{20} = \frac{9}{20}$

$\frac{1}{5}$

$\frac{1}{4}$

Each fraction is expressed as the number of shaded boxes / grid size.

Grid size is 20, which is the Lowest Common Multiple of 5 and 4.

☐ Quiz
☒ Demonstration

Show solution

Exit

Draw AutoShapes

Ready

start

NUM

Microsoft Excel - C:\Multiply.xls [Read Only]

File Edit View Insert Format Tools Data Window Help

100%

Multiplication of fractions

Grid size: 8 x 2

$$\frac{7}{8} \times \frac{1}{2} = \frac{7 \times 1}{8 \times 2} = \frac{7}{16}$$

Each box in the grid represents $\frac{1}{16}$ ($8 \times 2 = 16$).

7 x 1 shaded boxes represent the answer.

So the final answer is $\frac{7}{16}$.

Quiz
Demonstration

Introducing New example Show solution Exit

Draw AutoShapes

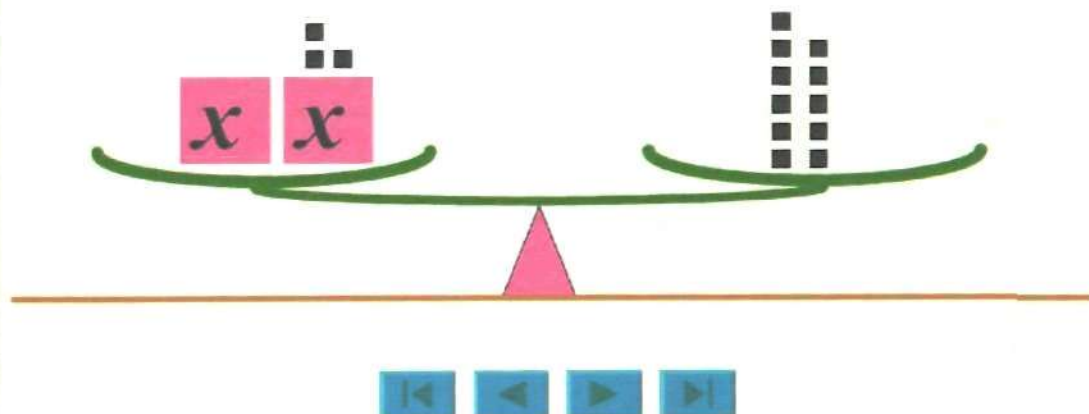
Ready

start C:\Proctions Program\K2\K2000\Excel\Microsoft Excel - C:\Proctions

Equations

Example 2

$$2x + 3 = 11$$



Example 2

$$4x - 7 - x = x + 14 - x$$

$$3x - 7 + 7 = 14 + 7$$

$$\frac{3x}{3} = \frac{21}{3}$$

$$x = 7$$

subtract x from both sides

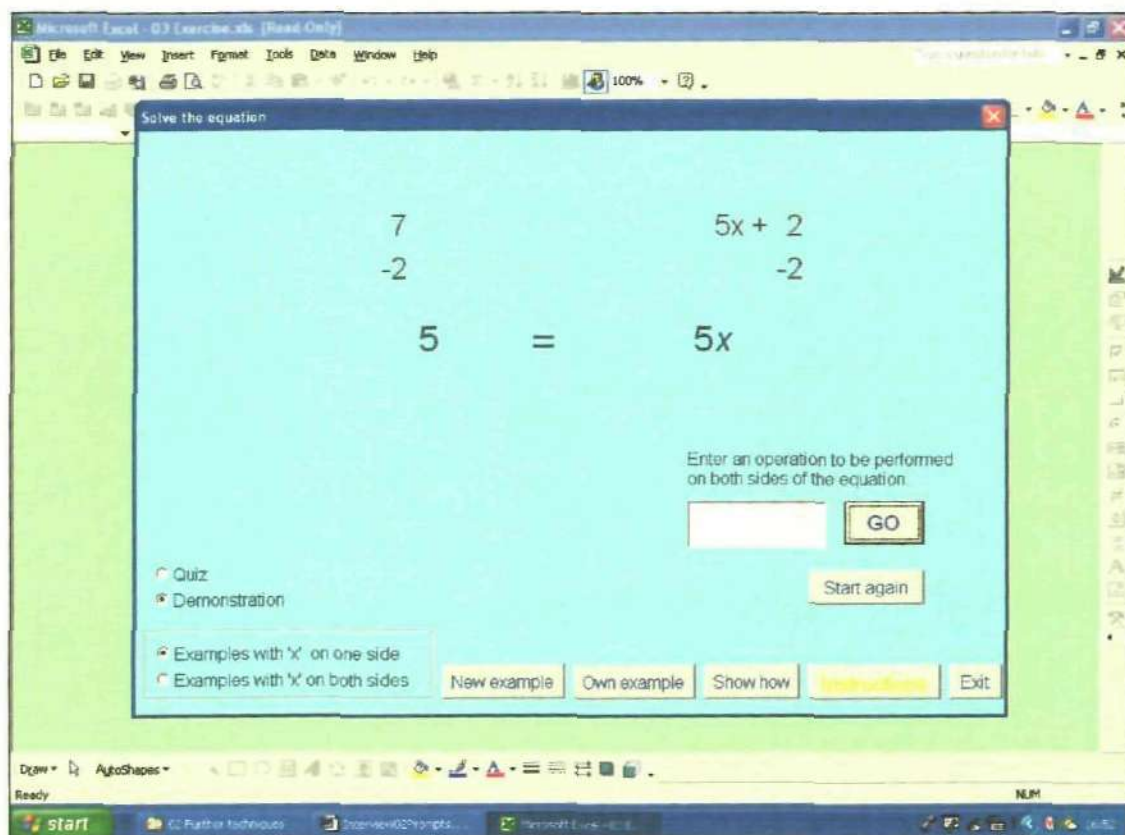
simplify

add 7 to both sides

simplify

divide both sides by 3

simplify



Transposing formulae

$y = (b + c) e$	$\underline{b = ?}$
$\frac{y}{e} = (b + c)$	<i>÷ e both sides</i>
$\frac{y}{e} - c = b$	<i>simplify</i>
$\underline{\underline{\frac{y}{e} - c = b}}$	<i>÷ e both sides</i>
$\underline{\underline{\frac{y}{e} - c = b}}$	<i>simplify</i>

Indices

Microsoft Excel - INDICES.XLS [Read Only]

File Edit View Insert Format Tools Data Window Help

100%

C19

Indices

a to the power 2

a is the number. 2 is the index.

a^2 means $a \times a$

H < > H \ Demonstration \ Rules 1 \ Rules 2 \ Exercise 1 \ Exercise 2 \ Exercise 3 /

Draw > AutoShapes >

Ready

start C:\Algebra\ Demonstration\Prompts... Microsoft Excel - INDICES

Microsoft Excel - Example1.xls [Read Only]

File Edit View Insert Format Tools Data Window Help

100%

Examples

Type 1 Type 2 Type 3 Type 4

3 8

a

$a^3 a^8 = a^{11}$

Show answer

H < > H \ Example 1 /

Draw > AutoShapes >

Ready

start C:\Algebra\ Demonstration\Prompts... Microsoft Excel - Example1.xls

Microsoft Excel - Example1.xls [Read-Only]

File Edit View Insert Format Tools Data Window Help

100%

Examples

Type 1 Type 2 Type 3 Type 4

$$\frac{a^8}{a^3} = a^5$$

Show answer

Example 1/

Draw AutoShapes

Ready NUM

start

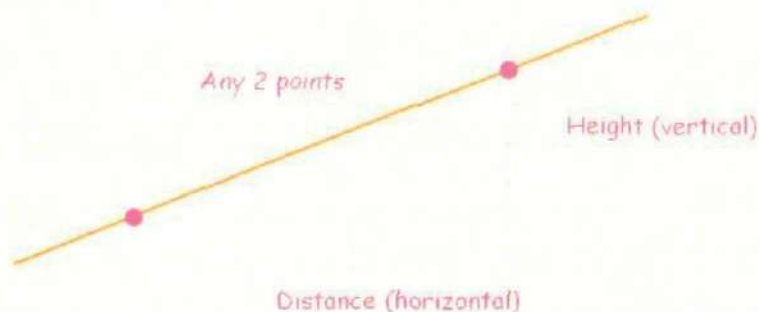
01 Algebra 1

Example1.xls

Microsoft Excel - Example1.xls

Graphs and equations

Mathematical definition



$$\text{Gradient} = \frac{\text{Height}}{\text{Distance}}$$

Example 3

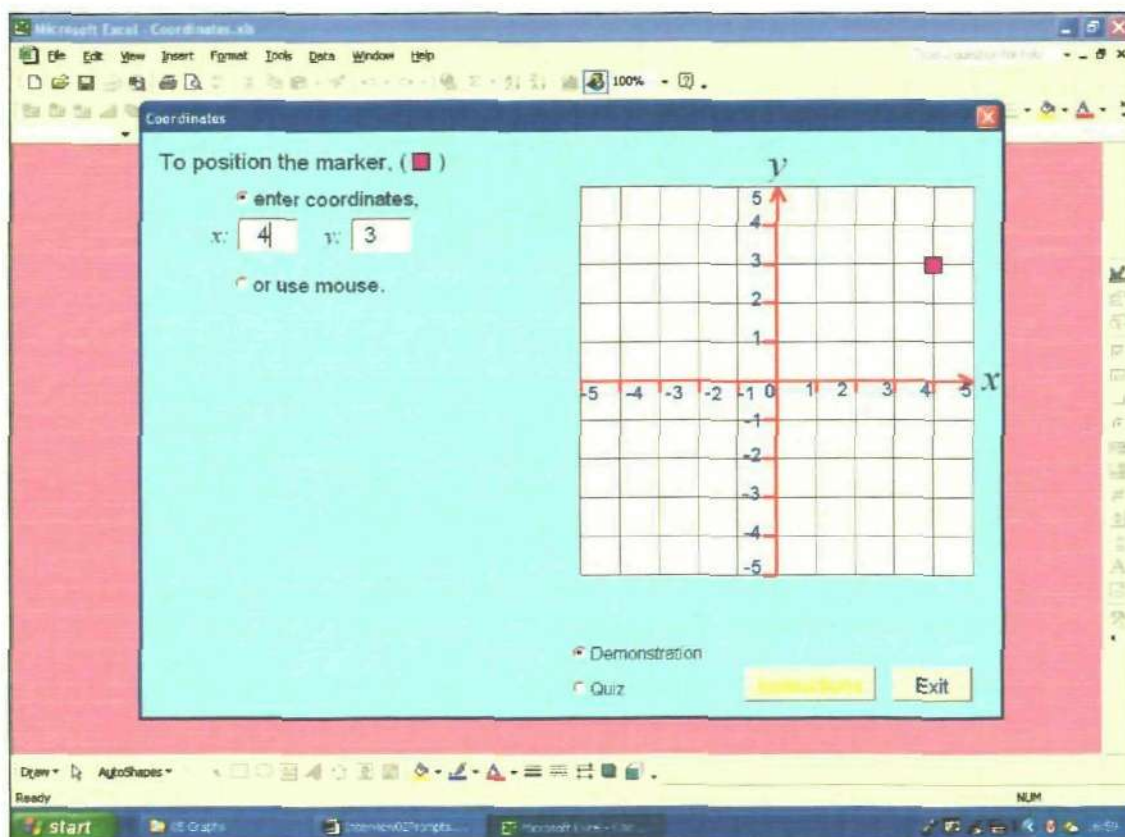
Example 2

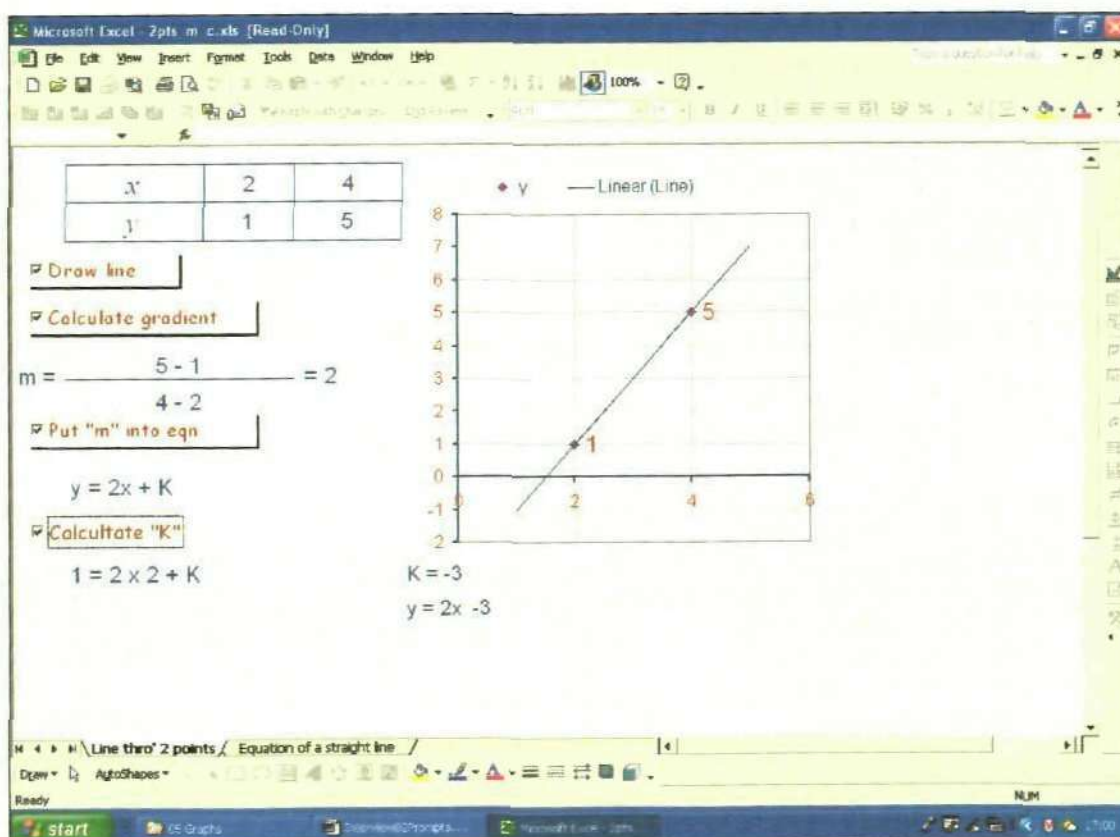
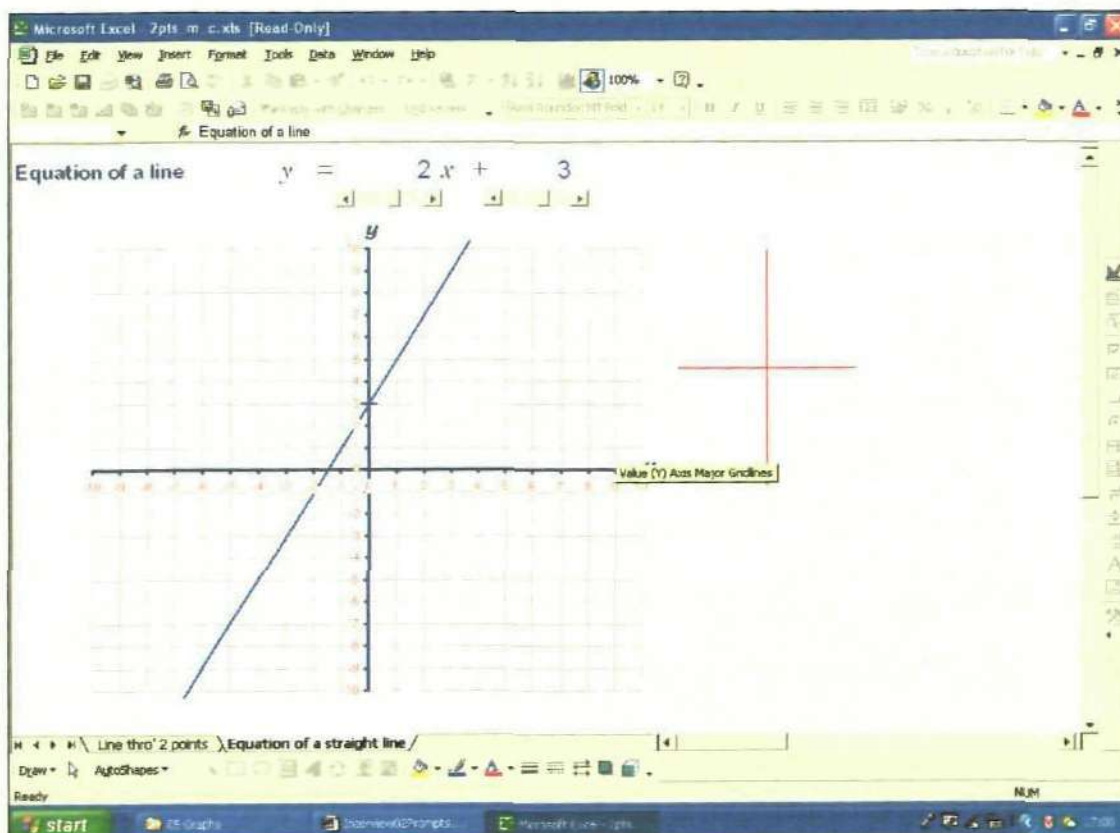
Example 1

Example 4

Example 5

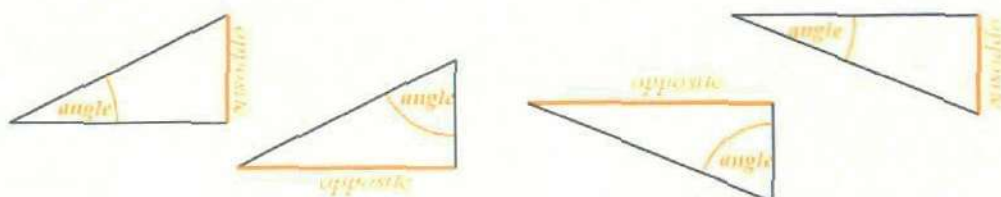
Example 6





Trigonometry

Opposite side: *the side opposite the angle*



Opposite side

Adjacent side

Hypotenuse

Contents

Terminology

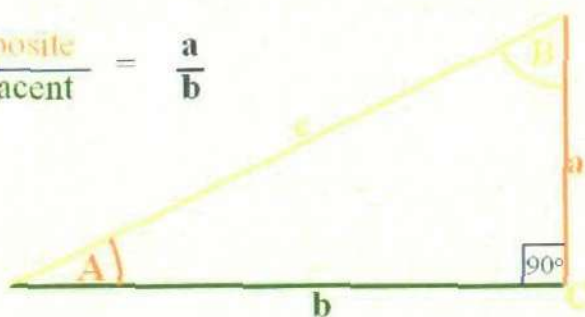
Definitions

Exit

Tangent of angle A

$$\tan(A) = \frac{\text{opposite}}{\text{adjacent}} = \frac{a}{b}$$

$\tan(B)$



clear

Sine

Cosine

Contents

Terminology

Definitions

Exit

Appendix G: Transcript of interviews

1 Interview with Student 1

- 2 Tutor: This is Tutor: and I am talking to _____. Can you tell me, was
3 there any topic or part of the course which you found particularly
4 difficult?
- 5 Student: No, I just had a slight problem with the indices, that was all.
6 Thinking about that, everything else was ok.
- 7 Tutor: You are looking at a list of topic areas. Are there any of the topic
8 areas that stand out.
- 9 Student: Certainly I found the graph stuff helpful, doing it with the computer
10 technology, being able to visualise the graph, how it changed and so
11 on.
- 12 Tutor: Can I just look up the section on graphs? I am looking at top
13 diagram page 9. This is where we started, with the gradient. Is that
14 the area you are talking about?
- 15 Student: Yes, being able to alter the gradient and coordinates and see the
16 gradient come through.
- 17 Tutor: I am looking at page 10, that was the graph one. Is that the one
18 you found good?
- 19 Student: Yes, just being able to visualise the equations from the graphs.
20 Trigonometry as well I found useful.
- 21 Tutor: I am looking at page 11. You found these slides...?
- 22 Student: Yes, I found those quite useful. Just to be able to imprint it on my
23 mind.
- 24 Tutor: The main benefit was the visual aspect of it?
- 25 Student: Yes.
- 26 Tutor: Can we go back to the indices? You said you weren't happy with
27 that.
- 28 Student: Yes, that was the only topic I found....
- 29 Tutor: How do you feel about indices now?
- 30 Student: Well, having you explain it, it must have gone in and not stuck. That
31 was the only one I didn't get a grasp on.
- 32 Tutor: You are going to have a test tomorrow. You are going to have a
33 question on indices. How do you feel about that?
- 34 Student: I am sure I will be a lot better
- 35 Tutor: what about the way that was delivered? The presentations.
- 36 Student: I think the delivery was ok, it is just me.

- 37 Tutor: I am looking at page 7 now. We used this projection onto the board.
38 At the time did it seem reasonable and logical?
- 39 Student: Yes, it did.
- 40 Tutor: But coming back to it?
- 41 Student: (Background noise)
- 42 Tutor: Did you use the software on logarithms?
- 43 Student: Yes, and I found that quite useful.
- 44 Tutor: You find that useful?
- 45 Student: Yes.
- 46 Tutor: Overall on the course what benefit, if any, do you think you've got
47 from the two weeks?
- 48 Student: I've certainly recalled... I've studied all this... It's just
49 really...refreshed everything in my mind...I'm very confident, much
50 more confident now...
- 51 Tutor: You said on your initial survey you wanted to brush up on your
52 maths. Did you feel you've done that?
- 53 Student: Certainly yeh, definitely.
- 54 Tutor: Do you feel more confident at maths than you did before?
- 55 Student: Yeh
- 56 Tutor: Thank you _____.

57 Interview with Student 2

- 58 Tutor: This is Tutor: and I am talking to _____.
59 What I would like to ask you to begin with, was there any topic on
60 the course that you found particularly difficult?
- 61 Student: No, not really.
- 62 Tutor: Were you fairly confident with most topics before you came on the
63 course?
- 64 Student: Yes.
- 65 Tutor: If we look at some of these diagrams, - that's the different topic
66 areas - as we go through these can you let me know if any of these
67 strike you as having been particularly useful or particularly not
68 useful?
- 69 Student: I think this one on fractions was useful. I mean, I can do fractions
70 anyway. It was just a matter of refreshing myself with this course,
71 but I think this is one is set out quite well.
- 72 Tutor: I'm looking at page two. You mean this one, on addition? When you
73 say it is set out well?
- 74 Student: The way the grids are going and the addition and the multiplication I
75 think as well - yeh - you can just see it easier - I mean I can do it

76 anyway - but the way it's split vertically and horizontally on these
77 grids...

78 Tutor: So that rang a chord with you, did it?

79 Student: Yes, I think so, yes

80 Tutor: You say, you could do fractions anyway?

81 Student: Yes.

82 Tutor: But that...

83 Student: You could visualise it more. Rather than just use numbers, you
84 could visualise it I think.

85 Tutor: Do you like to visualise things?

86 Student: I think you get a better understanding of it if you can visualise it. So
87 it helped me probably get a better understanding - I mean I could
88 come up with the answers anyway - but it helped me get a better
89 understanding of them.

90 Tutor: Do you remember we talked about this BODMAS rule? - Order of
91 precedence?

92 Student: Yes.

93 Tutor: Were you familiar with that before?

94 Student: Yes, but I can't really remember it - I mean I think I sort of did it
95 without thinking about it but I think it was helpful that we went over
96 that again

97 Tutor: What about equations, were you happy with these?

98 Student: I knew - I was happy with this - I knew about the balancing and
99 using the algebra anyway.

100 Tutor: What about transposing formula?

101 Student: I'm glad we went back over this, because this is something I haven't
102 done for a long time and I was looking through some textbooks and
103 I forgot how to do some of this transposition. I would move it around
104 and it would be in the wrong places. So I found this very useful
105 really. I mean, I don't know if it would have made much difference
106 doing it on the projector or if you just did it on the board.

107 Tutor: So when you embark on the course, if you were told that the course
108 was going to use this type of presentation with the projector and
109 computer, you wouldn't be too bothered if you were told that was
110 going to happen or whether they said, we're not going to use that;
111 we're just going to use a conventional white board.

112 Student: No, I wouldn't be bothered. I don't think it would make much
113 difference to me - not really.

114 Indices, again, I'm glad we went back over this. I've done it but it
115 was along time ago. I enjoyed that; apart from I got slightly lower
116 marks than I should have done because I should have revised for
117 this. Because I found it quite easy going over it, the weekend I
118 spent going through graphs and then I got a slightly lower mark than

119 I anticipated.
 120 I enjoyed it. Graphs, graphs, this is something that I couldn't
 121 remember how to do. This is one of the things that I thought I need
 122 to go over. That's why I spent the weekend last weekend going
 123 through it.

124 Tutor: Working out the gradient?

125 Student: Not gradients. Working out the equation from graphs. I forgot how
 126 to do that. I got a lot from that.

127 Tutor: You say you got a lot from that. Do you mean this actual computer
 128 material or the material in the book or a bit of both?

129 Student: Both, both, definitely.

130 Tutor: When you say both, did you find them complementary then?

131 Student: Yeh, I think they were complementary, definitely on graphs,
 132 and trig, trig I had a good understanding about before. I've used
 133 trigonometry in the last couple of years anyway. So that was quite
 134 easy really.

135 Tutor: You said on your initial questionnaire, what you expected to gain
 136 from the course was, "to refresh my knowledge and maybe learn a
 137 bit more?" Do you feel that you've actually managed to do that?

138 Student: Yes, definitely. I think I would have sat the exam paper – before I
 139 did these two weeks - and probably got - I don't know - 75% ish
 140 anyway, but I've come in and I've got 92% - I mean a couple of
 141 mistakes I could have - I should have got 100 but -
 142 It definitely refreshed me and it helped me bring back some of the
 143 skills that I have used before and I have learnt a little bit more as
 144 well. We covered a bit on logarithms. It's accomplished what I hoped
 145 it would.

146 Tutor: You say about logarithms, there was a bit of software along with
 147 that.

148 Student: That was helpful.

149 Tutor: Did you look at the CD?

150 Student: No, I should have done.

151 Tutor: Is there anything else that you want to mention about the course -
 152 anything that you think might be significant?

153 Student: I don't think so. I mean, I would recommend this course for anyone
 154 who would like to - who's not sure of their level - or would like to
 155 refresh themselves like I did. It gives you the confidence to start the
 156 Foundation Year.
 157 I feel quite comfortable now, knowing I should be alright.

158 Tutor: Thank you very much.

159 **Interview with Student 3**

160 Tutor: This is Thursday and I am talking to ...

161 Student: I'm _____.

162 Tutor: If I can start by asking you, was there any particular topic or aspect
163 of the course you found difficult? Does anything stand out?

164 Student: I did have trouble with the graphs and the indices – mainly were my
165 problem areas.

166 Tutor: Lets talk about the graphs then. Were graphs a problem before?
167 You've done maths at some stage before.

168 Student: A long time ago!

169 Tutor: A long time ago.

170 Student: The graphs, really I just – I mean really in the end it turns out that
171 it's not as hard as I thought it was, but I was always looking for
172 something else I think that ...

173 Tutor: You've got a test tomorrow. There's going to be a question on
174 graphs. How do you feel about it?

175 Student: OK.

176 Tutor: OK?

177 Student: I think - I think I'll get it - the majority of it right.

178 Tutor: We didn't use much technology for actually teaching graphs. We did
179 a little bit. Can we look at this [printed examples from material
180 used], Is that the relevant area we are talking about in graphs. This
181 is, essentially graphs of straight lines.

182 Student: Yes. That actually – it appears quite - quite straightforward, doesn't
183 it, like that.

184 Tutor: It looks straightforward like that?

185 Student: Yes, yes

186 Tutor: If you have any apprehensions about graphs, what are the
187 apprehensions you have?
188 What are the difficulties? – if any

189 Student: Just understanding what they want from me - even though that
190 every time I answer the questions on graphs I seem to have got the
191 correct answer.

192 Tutor: Do you mean the actual plotting of the graphs? Like, if you get a
193 question that says, "Here's some data. Plot a graph."

194 Student: I think the equation of the line - I don't really seem to understand
195 what they are asking for, although I get it right every time.

196 Tutor: Right. Lets move on from graphs. Are there any other topic areas
197 which come to mind as being particularly difficult or particularly
198 easy?

199 Student: Indices, changing - Indices I found quite difficult when you started
200 to talk with the cube roots, and square roots and changing over, and
201 brackets. Although I've got a much better understanding now than I

202 did before the course, I still feel that I could carry on and improve
 203 my skills there.

204 Tutor: So, you have a much better understanding than you had before? is
 205 that what you said?

206 Student: I have a much better understanding of basically everything in the
 207 course because I came to this class with nothing really.

208 Tutor: Sticking with the indices then, if I can show you the page - these are
 209 some of the presentations - I'm looking at page 7, on indices.
 210 Can you comment on these?
 211 Did that make a difference one way or another? - this type of
 212 presentation
 213PAUSE.....
 214 Do you remember seeing that on the board?

215 Student: Yes, I do, I do yeh.

216 Student: This makes sense here.

217 Tutor: So you were happy with the basic concept of indices?

218 Student: Yes, yes

219 Tutor: and the simple multiplying, dividing, and the simple rules of adding
 220 the indices or subtracting the indices? Was that OK after the initial
 221 presentation?

222 Student: Yes, no I mean I completely understood the basics of it.

223 Tutor: So are you saying that it's when you get a fairly complicated one
 224 that you have to work out on paper and put them together?

225 Student: Definitely.

226 Tutor: Do you feel totally daunted by something like that?

227 Student: No, not at all.

228 Tutor: Again, you're going to have one in the test tomorrow...

229 Student: I feel I can get eight out of ten right. But I just feel I could learn
 230 more about this area.

231 Tutor: Thinking about the course in general, you have a few reminders
 232 there. If you were going to go on another maths course and you
 233 were told that it will be presented similarly to this one - in other
 234 words, we will use the data projector and we'll use that type of thing
 235 [referring to material] - how would you feel about that?
 236 If you had the choice of one where they were going to use this type
 237 of presentation using the projector and that type of software and
 238 there was another one where they weren't going to use it, would you
 239 have a preference one way or the other?

240 Student: I would prefer a mixture. I feel that there is a lot to be gained from
 241 the projector and also there's a lot that would be lost in a classroom
 242 without the blackboard methods being used in certain occasions.

243 Tutor: Would you be able to say what type of thing is gained with the
 244 projector?

- 245 Student: The questions can be put over more accurately. Whereas I think the
 246 blackboard method could be used just to – with queries that
 247 someone maybe asks the teacher to explain quickly. Things that you
 248 can't do with a projector.
- 249 Tutor: On your initial survey you said what you hoped to gain from the
 250 course was a better understanding for mathematics and to overcome
 251 some previous fears in tackling equations. Do you think you have
 252 managed to achieve that? Or, do you think we have managed to
 253 achieve that?
- 254 Student: Absolutely, absolutely. As I say, I came here with nothing, and since
 255 1984 – was the last time I did any maths at school and I didn't do
 256 very well then either, - so basically, everything that I've learned
 257 about maths I've learnt in this two weeks.
- 258 Tutor: OK. thank you very much, _____.

259 **Interview with Student 4**

- 260 Tutor: This is Tutor: talking to _____.
- 261 Tutor: Can you tell me was there any part of the course that you found
 262 particularly difficult?
- 263 Student: Not really, really difficult, but the hardest bit for me was indices.
 264 Everything else was OK.
- 265 Tutor: How do you feel about indices now?
- 266 Student: Better than I did. It's been made clear to me now. I think it was a
 267 case of learning the rules and understanding why we did what we
 268 did. I am a lot clearer on it now.
- 269 Tutor: Did the presentation material that we used have any sort of effect on
 270 you. Did you think, "Oh, this is good", or "that was bad."
- 271 Student: Yes, presentation was ok. I think we did examples as well didn't we
 272 ourselves on our disc.
- 273 Tutor: That was logarithms which was very similar.
- 274 Student: That is what I am thinking of. I understand what we are doing now.
 275 Yes that was good, yeh, that was OK. That helped on indices. We
 276 did A times A times A times A.... that did help on that one.
- 277 Tutor: In general with that sort of presentation using the projector, did you
 278 take to that or would you think, "I'd rather have had the
 279 whiteboard."? did it affect you one way or the other?
- 280 Student: I was a little bit put off by the computer. Because my eyesight isn't
 281 brilliant, but I'm rather loath to wear my glasses, I did struggle a bit
 282 on some of them – not all of them, but some of them I did struggle a
 283 little bit.
- 284 Tutor: Was that the size?
- 285 Student: Yes, the size of the text and sort of some of the colours.
- 286 Tutor: In general do you use a computer a lot?

287 Student: Yes, I do at home, yes.

288 Tutor: Were there any topic areas where you thought the sort of
289 presentation and the use of the computer graphics actually hindered.

290 Student: Yes; for me personally was fractions. I just couldn't get this grid
291 idea at all. If anything, that actually confused me more. But then,
292 whether it was because I already was quite au fait with fractions and
293 you were trying to teach me another method, if you like.

294 Tutor: I am looking at page 2 here, this is the fractions. So, that's the
295 addition, and the multiplication

296 Student: That actually confused things for me because I knew how to do it
297 before and that actually...[Pointing to page]... I don't understand
298 what you're doing there.

299 Tutor: That is the sort of thing I want to know. Were you familiar with
300 Bodmas before?

301 Student: No.

302 Tutor: You weren't?

303 Student: No.

304 Tutor: Are you now?

305 Student: Yep.

306 Tutor: Did that help?

307 Student: Yes, totally. Yes, totally. Because now I can see where I'd been
308 making silly mistakes over the past years and that is because of that
309 BODMAS. I didn't know that before and that did really help.

310 Tutor: Is there anything else about the course that you want to mention,
311 any features either good or bad, or that you think could be
312 improved?

313 Student: No, not really. I thought it was really good 'cos I mean that just
314 helped me sort of get my 'cos I thought ... I was like I was
315 panicking a bit before I came thinking I was a bit too thick to do it.
316 I'm thinking, "What am I doing? How do I possibly think I could do a
317 maths degree?" and that has made me feel a lot better, a lot more
318 confident, and just refreshed some things in my mind that I did
319 actually know but just dragging them back from memory. D'you
320 know what I mean. So that's just refreshed a few things. I feel a bit
321 more confident....

322 Tutor: I think you said on your initial questionnaire, you wanted to brush up
323 on your basic maths and get your brain into gear. Do you feel that
324 you have done that?

325 Student: Yes, definitely, without a doubt. Definitely, without a doubt

326 Tutor: Thank you very much.

327 Student: That's alright. No problem.

328

329 **Interview with Student 6**

330 Tutor: This is Tutor: talking to _____. OK, tell me, were there any topics
331 on the course you found particularly difficult.

332 Student: I wouldn't say I found them particularly difficult. I think the hardest
333 part on the course was definitely the fractions part. I put in my
334 questionnaire as well, I think, that really was the fact that, I think
335 what would have been helpful was if you had long multiplication and
336 long division put in with it, because I think some of the numbers
337 were quite big and considering what the topic is, it would have been
338 quite easier if you had, if you could actually work with the numbers
339 on paper, instead of relying on a calculator.

340 Tutor: So, when you come to do actual division you think that should treat
341 long division as a separate topic before we do fractions?
342 Is that what you are suggesting?

343 Student: Yes, I think it should either run, either before that or adjacent with
344 that really.

345 Tutor: How do you feel about fractions now?

346 Student: Far more confident, than when I initially started them.

347 Tutor: Was there any particular factor you found useful in gaining that
348 confidence?

349 Student: Yes, I would say the whole method, the layout of all the notes and
350 everything like that. I thought it was very well presented and it gave
351 you great confidence, and everything was well explained.

352 Tutor: What I am particularly interested in, is how effective were these
353 computer presentations. If I hadn't used these computer
354 presentations on the fractions, would it have made any difference?

355 Student: I wouldn't have probably said a great deal of difference. I'm not ... I
356 didn't think these boxes particularly helped.

357 Tutor: That is the first diagram on page 2. So that didn't help.

358 Student: No, I think the boxes confused the issue slightly, but the actual
359 methods with the numbers and fractions was far better.

360 Tutor: What about this for addition of fractions? Was that helpful or not
361 helpful?

362 Student: Yes, again that's what I mean. I don't think the diagrams are
363 necessary, to be honest. I think they confuse the matter.
364 Personally I think the numbers and the methods shown there are
365 quite adequate on their own.

366 Tutor: Can you think of any topic areas throughout the week - here is a list
367 of the different topic areas we went through - were there any which
368 particularly stood out for a positive or a negative reason? Like, did
369 you think, "Oh that's suddenly clicked," or did you think, "Oh gosh,
370 I didn't really like that."?

371 Student: For me, probably the rearranging the formula, 'cos it's always been -
372 maths hasn't really ever been too big a problem - but rearranging

373 formula has always been the part, that if anything was likely to go
 374 wrong that would be the part that would go wrong. And that's
 375 certainly cleaned that up.

376 Tutor: You are quite happy with transposing formula now then?

377 Student: Yeh

378 Tutor: If I look at... - that is an example one of the bits of software. What's
 379 your reaction to the way that was presented, using the projector?

380 Student: It's good, 'cos it shows - from what I remember at A level, it was
 381 more or less; you would have the beginning and then you'd have the
 382 answer but you wouldn't have an explanation all the way through -
 383 so that shows you step by step. So it gives you a far clearer
 384 understanding of what's actually happening.

385 Tutor: Did you know about BODMAS?

386 Student: No, I didn't.

387 Tutor: You didn't. Are you happy with it now?

388 Student: Yeh, I'm happy with it now

389 Tutor: What did you think about the way that was presented?

390 Student: I think it was presented very well but I'm not - the whole BODMAS,
 391 concept if you like - I'm not too sure about it - this word that is that
 392 is used to describe this - personally I wouldn't use it again. BODMAS
 393 would probably not be something that I would particularly
 394 remember.

395 Tutor: You mean the mnemonic, the actual word, "BODMAS"?

396 Student: Yes.

397 Tutor: Are you happy about using the rules?

398 Student: Yes, the rules about I'm happy.

399 Tutor: Did you find you had enough time to think about or reflect on what
 400 we were doing on the course? -Thinking of the balance between
 401 doing things and being allowed to think about them.

402 Student: Yeh, I think it was fine.

403 Tutor: I can't remember what you said the reason - on your questionnaire
 404 we asked you what do you think you are going to gain from the
 405 course. Do you think you've got what you wanted from it?

406 Student: Well, when I accepted coming onto the course, I thought - my main
 407 interest was what the level was going to be, required to start the
 408 foundation year on. I think without a doubt it's given me a
 409 confidence boost, 'cause I now know what sort of level I'm expected
 410 to be at for when I go onto the Foundation Year now instead of going
 411 in completely blind.

412 Tutor: Is there anything else you want to mention?

413 Student: No, I thought it was all very well run. I thought it's been perfectly
 414 fine.

415

416 **Interview with Student 7**

417 Tutor: This is _____. There is the list of topics. Was there any topic or
418 part of the course that you found particularly difficult?

419 Student: Not really. Initially I feared some of the topics but once I
420 understood the rules that made it a lot easier for me to understand.
421 I think that where I thought that I was bad at maths before, it was
422 that I'd forgotten about certain rules and ways of doing things, and
423 then once I re-learnt that, and it came back to me, then I was better
424 at doing it.

425 Tutor: Was there anything you could have understood better had it been
426 presented differently?

427 [long pause]

428 Student: I don't think so. I think it was presented quite well.

429 Tutor: Was there anything where you found the presentation particularly
430 helpful; where you could say, "that was good."

431 [long pause]

432 Tutor: Just if anything stands out. If it doesn't...

433 Student: Some of the stuff that you did on the graphs today with excel, and
434 that kind of thing, you know where you could change things
435 dynamically. That made some of it easy to understand I suppose for
436 the rest of them.

437 Tutor: What about for you?

438 Student: Well, I pretty much knew what was going on anyway.

439 Tutor: You were quite familiar with that already? [Silent affirmation]
440 Were there any sessions which actually stood out either because you
441 found them easy or because you found them particularly difficult?

442 Student: Graphs, I found very easy.

443 Tutor: Had you done them before?

444 Student: Yes, not very long ago as well, that was the thing. I started taking
445 an Access course last September but dropped out because it was the
446 wrong combination of subjects.

447 Tutor: I used the data projector quite a lot. How did you find the use of
448 that computer-based material by me? Was it helpful or was it not
449 helpful? Do feel strongly one way or the other?

450 Student: I think it was helpful and that was actually the first time that I'd
451 seen maths taught in that way, using Macros and spreadsheets and
452 PowerPoint presentations.

453 Tutor: In what way was it helpful?

454 Student: You could easily break it down into steps and you could see what
455 was going on.

456 Tutor: I gave you some computer-based material – up in the lab. How did
 457 you find using that? Was that useful or not useful or...?

458 Student: Yeh, it was fairly useful.

459 Tutor: Was it any better than doing it on paper?

460 Student: Sometimes it's too easy to just manipulate figures on the computer
 461 and think that you are understanding it. Whereas when you write it
 462 out you're putting it in your way and that makes it sink in your head
 463 better I think.

464 Tutor: How about assessment, the way the course was assessed?

465 Student: I thought that was good.

466 Tutor: Could you say in a few words how you think you have benefited from
 467 the course?

468 Student: I benefited in that I came onto this course thinking that I needed to
 469 do it because I thought my maths skills were poor which was really a
 470 reflection of the fact that I hadn't used them for so long and it was
 471 just rusty.

472 Tutor: Is there any else, any comment you want to make about the course?

473 Student: I think it has helped me even though I am leaving early but I feel
 474 the topics you are covering here, I now understand them.

475 Tutor: Thank you very much.

476 **Interview with Student 8**

477 Tutor: This is ____ and it is Thursday today.
 478 Was there any topic you found particularly difficult?

479 Student: No, not really They were all at the same sort of level.

480 Tutor: Had you come across this BODMAS Rule before?

481 Student: Yeh, I remembered it from school. What each letter stood for.

482 Tutor: So, you are quite happy using it?

483 Student: Yep.

484 Tutor: There wasn't any particular topic you found difficult?

485 Student: I found fractions a bit difficult at first, probably because it was our
 486 first test. But now we have been learning other things, I find it a bit
 487 more easier.

488 Tutor: Just going back over the week, are there any sessions that you can
 489 remember as thinking either; that was good, that meant something
 490 to me; or that was particularly confusing or wasn't very good. Are
 491 there any that stand out, one way or the other.

492 Student: No, not really

493 Tutor: Looking through the slide shows that we looked at, I just want you
 494 to tell me if there are any of these that you might say 'that was
 495 good' or 'that was bad' or that was confusing,

- 496 Student: I think the fractions one was quite good because it actually showed
497 the fraction in graphic sense rather than a number. It showed, say
498 for example if it was a quarter, it showed a quarter of something.
- 499 Tutor: Did that help you then?
- 500 Student: It helped a bit.
- 501 Tutor: That one was equations. Were you OK on equations?
- 502 Student: I was OK on equations, Yeh. I did like the way that it showed
503 everything step by step and explained it really well.
- 504 Tutor: What about transposing formula? How do you feel about transposing
505 formula?
- 506 Student: I found it quite simple. What I found a bit difficult is making a
507 formula for a written question. Just transposing in general was ok
508 though.
- 509 Tutor: Could you do that before?
- 510 Student: No, everything I learnt really, is from the revision book ... so far.
- 511 Tutor: What about indices then?
- 512 Student: Indices. I found it difficult at first because there was quite a lot of
513 rules you need to learn, just like what to power of the 2 is, what
514 power the minus 2 is, power to a fraction and then plusing them
515 dividing them. There's quite a few rules but now I've practised it a
516 few times I'm finding it easier.
- 517 Tutor: You've got a test tomorrow and there will be a question on indices.
518 How do you feel about that?
- 519 Student: Quite confident really.
- 520 Tutor: Had you done indices before? Before you came on the course?
- 521 Student: I've probably done it all of this before but it's been like ten years. I
522 can't remember anything. I feel like I am starting from the
523 beginning.
- 524 Tutor: I am looking at page 7. The way it was done there, was that ok or
525 would you have preferred that I hadn't used that and just, say, done
526 on the board.
- 527 Student: No, I think it's very good using the computer because, like I said, it
528 shows everything clearly and it's good to see it on computer rather
529 than just written up, I think. It looks better.
530 Plus, you gave us a CD which we can go over again if we wanted to
531 at home.
- 532 Tutor: Did you use that CD much?
- 533 Student: Yes, I used at home, just to go through things, just a recap on what
534 I've done, ready for the test really.
- 535 Tutor: Did you find that useful?
- 536 Student: Yes.
- 537 Tutor: Did look at all of it or were there particular ones you found?

538 Student: Just what we done the day before, really. Had a quick check in the
 539 mornings.

540 Tutor: Is there anything else you want to add about the course in general?

541 Student: I just thought it was very good. I was a bit scared of coming at first
 542 but it's OK, it's good. It got me back in the swing of things. I know
 543 what to expect from university, in general. It's good. My brain has
 544 got back into exercising. It's been a bit dormant for a while.

545 Tutor: So have you got out of the course what you hoped to get?

546 Student: Yes. It's good. I did expect it to be much harder, but, I suppose
 547 that's a positive thing.

548 Tutor: OK. Thank you very much.

549 **Interview with Student 9**

550 Tutor: This is Tutor: and I am talking to...

551 Student: _____. Other people call me ____.

552 Tutor: Right, _____. Can you tell me; was there any topic or part of the
 553 course that you found particularly difficult?

554 Student: I found fractions difficult and still am having a few problems. I just
 555 can't get to grips with the concepts.

556 Tutor: Can I ask, what we did in class, we used some presentation material
 557 for fractions. Can you tell me what your reaction was to that?

558 Student: It was easy to understand and it explained how the fractions worked,
 559 the size of them, what you take away, but, because I am a Student:
 560 away at home I didn't get a chance to use the CD ROM software - at
 561 home - and the time in class was limited so I had to make what use
 562 I could of the projector and the teacher showing me. Otherwise the
 563 software I found to be very useful.

564 Tutor: So the basic presentation, you could follow that?

565 Student: It was understanding and simple.

566 Tutor: Were there any other topics that you found difficult?

567 Student: No, everything else was quite OK, just a bit rusty. If I do some
 568 practice and brush up on it I'll be fine.

569 Tutor: If we can have a look at some of the material that we used, were
 570 you familiar with this BODMAS rule?

571 Student: No. It's never come across me before. First time.

572 Tutor: You'd never come across that before?

573 Student: No.

574 Tutor: Does it make sense to you?

575 Student: Yes.

576 Tutor: What did you think about the slide presentation that was used for
 577 that?

578 Student: Well, of course, that has never come across before. So, I had to
 579 understand it for me to be able to go through the topics. Again, it
 580 was easy to understand and made it clear.

581 Tutor: You're going to have a test tomorrow and somewhere in there you
 582 are going to have to apply this order of precedence. Are you quite
 583 happy about that?

584 Student: Yes.

585 Tutor: Can we look at some of the others [other topics]. We've mentioned
 586 fractions. If you look at these diagrams, just to remind you of what
 587 we looked at, can you just comment whether any of them were
 588 particularly useful or not particularly useful?

589 Student: On the equations one, where you've got the scale and everything -
 590 that's on page 4 - easy to understand, but... I don't know, it's an
 591 easy equation for people who know how, but, I didn't find it useful
 592 because I knew what to do, but I don't know how other people would
 593 feel.

594 Tutor: Just think about what it meant to you.

595 Student: To me, it explained the difference of having 11 on one side and $2x$
 596 on the other. That's how I saw it. I can't explain it more because I
 597 understand what was going on.

598 Tutor: So you could solve the equation?

599 Student: Yes, I could solve the equation.

600 Tutor: So what I'm looking at on page 4 didn't make a lot of difference to
 601 you; you could do it already?

602 Student: Yes.

603 Tutor: What about transposing formula?

604 Student: I found the software which you used to be very handy and that. I did
 605 have a hard time at first, and as the software progressed it shows
 606 you step by step what's happened and what's been taken away. So it
 607 was quite easy to understand what's going on there.

608 Tutor: Would it have been just as effective if I had written it on the board?

609 Student: I suppose so, but with the software you saved a lot of time. So,
 610 more time-efficient.

611 Tutor: Other topics we looked at, had you done indices before?

612 Student: No, first time I've done indices.

613 Tutor: Well, again, you're going to have a question in the test tomorrow, on
 614 indices. How do you feel about that?

615 Student: I am not too sure how I feel. I wouldn't say confident, but I'm sure
 616 a bit of revision tonight, I've got a laptop now. So I'm going to flip
 617 through the CD and see what I can do.

618 Tutor: Can I ask you, in general, I used the projector quite a lot. How did
 619 you feel about that generally? By the end of the course are you

- 620 thinking, "I wish he hadn't used that projector so much?", or are you
 621 thinking, "I wish he'd used it some more", or you're not particularly
 622 bothered either way?
- 623 Student: Honestly it doesn't make a difference, but as, - I'd say I am new to
 624 Maths because I haven't studied for five years - using the projector
 625 and the software you were using made everything - it was well
 626 explained and easy to understand.
 627 I preferred the projector to the board.
- 628 Tutor: Any particular reason?
- 629 Student: It was all laid out for you. You didn't have the teacher moving from
 630 one side of the board to the other trying to explain something. It
 631 was there; all done for you and step by step what you wanted; you
 632 could always go back and could go forward.
- 633 Tutor: One of the questions we asked you on the initial questionnaire was,
 634 "What do you expect to gain from the course?" I don't know if you
 635 had an expectation, but do you think you have gained...
- 636 Student: Yes, an all round general knowledge of basic maths skills and to
 637 prepare me for the foundation year in engineering.
- 638 Tutor: Is there anything else you want to add?
- 639 Student: That's fine.
- 640 Tutor: Thank you very much.

641 **Interview with Student 10**

- 642 Tutor: This is Tutor: talking to _____. I am starting the interview now.
 643 What I'm interested in is how you found the use of technology. I am
 644 going to start by asking if there was any topic or part of the course
 645 you found particularly difficult?
- 646 Student: Certainly indices stood out as being the hardest thing for me to
 647 mentally get over.
- 648 Tutor: Was there anything during the course which could have made it
 649 easier?
- 650 Student: I did fill out a questionnaire with regard to indices that you did and
 651 in that I stated that I thought the computer helped a lot when we
 652 were doing exercises but there could have been more there. There
 653 was only one exercise available and it was at a certain level and it
 654 could have gone further.
- 655 Tutor: Was that the logarithms one that you are talking about?
- 656 Student: I'm talking about logs now. I am getting confused between logs and
 657 indices.
- 658 Tutor: That's alright. The logs you found difficult?
- 659 Student: Yes, logs and indices I would say - both of them I found slightly
 660 intimidating.
- 661 Tutor: Was there anything you found particularly easy?

662 Student: I would say the rest of the course.

663 Tutor: I am looking at page 7 on the prompts. That was the indices
 664 software. How did you find that? When I was using that, did you
 665 think, "This is good" or did you think, "I wish he wasn't using that,"
 666 or what? Did you have any reaction?

667 Student: My reaction isn't that good to this. Some of the software was of
 668 great help but you can see on this page, we had "A three" and
 669 "eight", but what I want then would have been "A three", another A
 670 here, so it goes "A eight", and then perhaps, here below, another
 671 line of "A three, A eight equals A three plus eight." This is a bit of a
 672 jump here for me. REFERRING TO LITERATURE.

673 Tutor: Do any of the other prompts stand out as being very helpful, very
 674 unhelpful?

675 Student: The algebra, with the balance I thought was beautiful. That was
 676 great.

677 Tutor: That is on page 4.

678 Student: The balancing of equations with the interactive scale, I thought that
 679 was fantastic. That really cemented the idea that you keep the
 680 equation equal on both sides.

681 Tutor: Did you say interactive scale?

682 Student: I don't think so?

683 Tutor: You liked the balance idea? What about that? That is still on
 684 equations, that is solving. AGAIN REFERRING TO LITERATURE.

685 Student: Does it go back one page?

686 Tutor: That is not a continuation of the previous one. Maybe you didn't use
 687 that one. If you don't have an opinion on it, it doesn't matter.

688 Student: I don't know what colour the minus 2 is but more profound colour
 689 would be good. So perhaps for every operation you make that a very
 690 bright red.

691 Tutor: Yes, that was black and white.

692 Student: Oh, maybe it was colour on there.

693 Tutor: Talking about the actual delivery, were there any topics or sessions
 694 which you can remember which you think could have been presented
 695 a bit better?

696 [A list of session was shown]

697 Student: The logarithms, the paper sheet we were given, I found very
 698 daunting. That worried me.
 699 My opinion of trig maybe differs slightly from your own in as much as
 700 I would have perhaps mentioned a bit stronger the other two rules
 701 because what always worries me when taking on a new concept is
 702 the idea that I won't be able to take the whole concept on board.
 703 Telling me that I'm only getting one third of the concept now, kind of
 704 scares me 'cos I think if I can't take this then I can't get the whole.

- 705 Tutor: So you would have liked to have Tan, Sin and, Cos all at the one go?
- 706 Student: I would have liked have them all introduced very briefly and then
 707 Tan concreted in, but maybe the three equations put up on the
 708 board. The other thing was, that I mentioned to Sam, when finding
 709 the opposite and adjacent and hypotenuse, I always take the beta
 710 angle and I imagine that is an eye and it's looking at the opposite
 711 side and I don't know if that would always fit, but for me that makes
 712 the difference between trig working and not working so I would have
 713 added that.
- 714 Tutor: Were there any topics or sessions that stood out as being particularly
 715 effective?
- 716 Student: Certainly the algebra, I was very impressed with. With the graphs, I
 717 thought that was very good but I thought there was room for
 718 improvement on the programme.
- 719 Tutor: Was that this one, page 10, bottom diagram?
- 720 Student: This use of scale; it's almost like on an A4 sheet of paper and I
 721 think, if it would be possible to give it a definite graph paper display,
 722 that would be good. I also think that to bring the graph alive like
 723 with a graphics calculator when it draws the line on and its moving
 724 as you see it, that make a big difference to how you feel about the
 725 line, I think. It was all good. I would be tempted to put the line
 726 across the whole page so going outside of the graph as well, so it's
 727 appreciated that the line is beyond the graph that you are looking
 728 because it is $y =$ something it continues for ever and that's the
 729 beauty of the equation.
- 730 Tutor: Thank you, that is good. Can you tell me generally what benefit do
 731 you think you've got from the course?
- 732 Student: I am certain that every presentation I have received completely
 733 concreted my knowledge of the subject. I don't think I learnt very
 734 much but what I already had learned was really reinforced by the
 735 course.
- 736 Tutor: You were fairly confident in most of this stuff beforehand? Is that
 737 reasonable to say?
- 738 Student: Yes, but only because I'd done the actual revision book before I
 739 arrived. So I'd done the exact course content before I came.
- 740 Tutor: You got some benefit then?
- 741 Student: I am positive every presentation I saw was worthwhile.
- 742 Tutor: On your first questionnaire, you said you could think of a particular
 743 experience that made you like maths and a particular one that made
 744 you dislike maths. Would you be happy to tell me about one or both
 745 of these? Tell me first of all, what made you like maths.
- 746 Student: What made me like maths was the idea that it could explain, like
 747 language can, the phenomenon that we experience in a way that I
 748 couldn't understand about it. Being something celestial, or

749 something on earth, maths is a language we need if we want to
 750 understand our universe and therefore I find it a beautiful thing.

751 Tutor: You said you could think of a particular experience that made you
 752 dislike maths. What was that?

753 Student: I would think that probably as a child at school, if I'd asked a
 754 question and the teacher hadn't given time to really think about
 755 stopping the question, that would make me dislike a subject.

756 Tutor: Did that actually happen to you at any point?

757 Student: I am pretty sure it did. A teacher can make a subject.

758 Tutor: Is there any other comment you would like to make about the
 759 course?

760 Student: The only thing for me, would be with the computer presentation, if it
 761 would be possible to display that on a whiteboard instead of a
 762 screen, I think that would be great. I think if you could have it up
 763 and if a Student: asked a question, you could then interact with what
 764 you've got up there on the whiteboard....

765 Tutor: Do you mean an interactive whiteboard?

766 Student: Just a standard whiteboard, and have it projected onto that and then
 767 when you've got to a point where anyone has a problem, rather than
 768 taking that away to another board and setting it up again actually
 769 being able to just write over what you've got from the computer,
 770 with your hand. I don't know how effective that would be but

771 Tutor: Thankyou for that suggestion. I am interested in what you think
 772 would be an improvement.

773

Appendix H: List of presentation software materials

Topic / Software	Description
Number	
BODMAS.pps	An example showing the order of precedence of operations. Calculation is shown line by line.
Add_Neg.pps	Addition & subtraction of negative numbers: The user specifies addition or subtraction of a signed integer; a kangaroo makes the appropriate number of jumps in the appropriate direction along a number line.
Fractions	
00 Fraction.xls	An $m \times n$ grid is shown, superimposed on a large unit-square. Both m and n can have independent values from 1 to 10, selected by the user or randomly by the computer. Each rectangle of the grid can be shaded or unshaded, selected by the user or by the computer. The user has to enter the numerator and denominator of the fraction which is shaded. In 'Demonstration' mode the user can specify the examples. In 'Quiz' mode examples are generated by the software and the user's answers are scored.
00 LCM_HCF.xls	Demonstrates examples of common multiples for pairs of integers, valued from 2 to 9. Demonstrates how to find prime factors. Demonstrates how to find HCF LCM of two integers specified by user or generated by the computer. In 'Demonstration' mode the user can specify the examples. In 'Quiz' mode examples are generated by the software and the user's answers are scored.
01 Equivalent fractions.xls	A common fraction is specified by the user or by the software. The user enters possible common factors of the numerator and denominator until the fraction is reduced to its simplest form.
01 Simplify.pps	This presentation illustrates graphically 12 examples of simplifying common fractions.

Topic / Software	Description
02 Add.xls	Two common fractions are added. The denominators may take independent values from 2 to 10. A pictorial representation of each fraction is shown as a partly shaded unit square. A grid superimposed on each unit-square corresponds to the common denominator. In 'Demonstration' mode the user can specify the examples. In 'Quiz' mode examples are generated by the software and the user's answers are scored.
03 Multiply.xls	Two common fractions are multiplied. The denominators may take independent values from 2 to 10. A pictorial representation of the answer is shown as a partly shaded unit square. A superimposed grid has vertical divisions corresponding to the one denominator, and horizontal divisions corresponding to the other. In 'Demonstration' mode the user can specify the examples. In 'Quiz' mode examples are generated by the software and the user's answers are scored.
Linear equations	
01 Examles.pps	This presentation illustrates the solution of 3 simple linear equations. The algebraic equation is shown above the picture a scale balance, on which a box represents the unknown variable and unit squares represent the numbers in the equation. As the equation is solved algebraically, units are added or subtracted correspondingly to or from the scales.
02 Examples.pps	This presentation shows two examples of the algebraic solution of a linear equation one step at a time.
03 Exercise.xls	This interactive demonstration invites the user to solve a linear equation by specifying operations and operands to be applied to both sides of the equation. In 'Demonstration' mode the user can specify the examples. In 'Quiz' mode examples are generated by the software and the user's answers are scored.
Rearranging formulae	
Ex_1.pps to Ex_7.pps	Each of the 7 presentations shows the step-by-step rearrangement of an equation.

Topic / Software	Description
Indices	
Indices.XLS	<p>Interactive demonstrations: e.g.</p> $x^4 = x \times x \times x \times x;$ $x^2 \times x^3 = x^{2+3}$ $x \times x \times x \times x \times x = x^5$ <p>User enters indices and expansions are shown.</p> <p>Rule for division and $(x^a)^b$ are also demonstrated.</p>
Example1.xls	Worked examples. User enters indices and then clicks on 'Show' button to reveal solution.
Graphs	
Coordinates.xls	<p>Demonstrates conventions of plotting points in the x-y coordinate plane.</p> <p>In 'demonstration' mode, user can specify coordinates and software plots point, or user can plot point and software shows coordinates.</p> <p>In 'quiz' mode the software can specify coordinates and the user must plot the specified point, or the software can plot a point and the user must enter the coordinates of the point. The user's answers are scored.</p>
LINE_THRO_2PTS.PPS	Two step-by-step examples are shown of how to sketch the graph and find the equation of the straight line through 2 specified points
Line thro 2 pts.xls	<p>The user can specify any two points on the coordinate plane.</p> <p>How to sketch the graph and find the equation of the straight line through the specified points is shown step-by-step.</p>
Y_mx_c.xls	<p>Demonstration showing the effect of the parameters, gradient and intercept with vertical axis, on the graph of a straight line.</p> <p>User adjusts parameters by means of 2 scroll bars; the graph alters accordingly.</p>
Trigonometry	
Trigonometry.pps	Presentation showing diagrams with definitions of opposite, adjacent and hypotenuse and trigonometry ratios.

Appendix I: End-of-summer-school test

1. Calculate and give answers as mixed numbers.

$$\text{i) } \frac{3}{7} + \frac{3}{14}$$

$$\text{ii) } 12\frac{3}{5} \times \frac{5}{21}$$

$$\text{iii) } 3\frac{1}{2} \div \left(\frac{1}{6} + \frac{1}{3}\right)$$

2. Solve the following equations.

i) $4x + 10 = 25 - 2x$

ii) $\frac{7(x + 5)}{2} = 49$

3. Three consecutive numbers add up to 54. What are the numbers?

4.

Make t the subject of this formula.

i) $F = \frac{mv - mu}{t}$

ii) Make C the subject of this equation

$$E = mC^2$$

5.

Express in the form $2^p \times 3^q$ and evaluate.

$$16^{\frac{3}{4}} \times (\sqrt{9})^3$$

ii) Simplify

$$\frac{\left(d^{\frac{5}{2}}\right)^4 \times d^{-3}}{d^{-1}}$$

6. The value a second hand car depreciates according to the formula

$V = 18000 - 1500t$, where V is the current value and t is the time in years.

i) Complete the table below and draw a graph to show how V varies with respect to t .

t	0	2	4	6	8	10	12
V							

ii) From your graph read and write down the value of the car after 7 years.

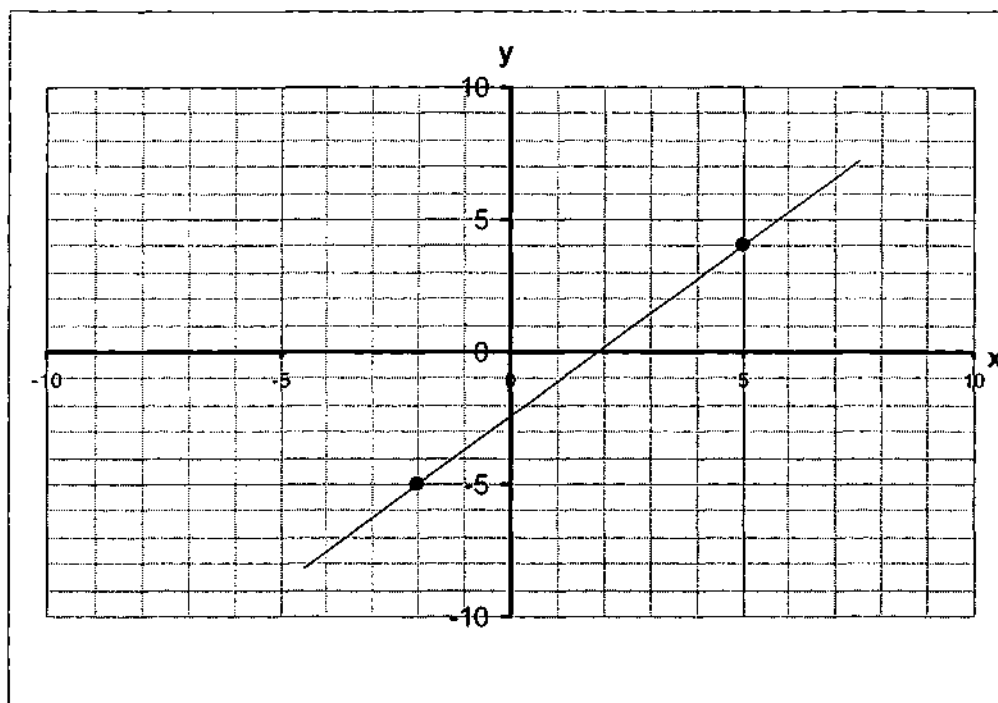
--

iii) Use the formula to calculate when the car will be worth half of its initial value.

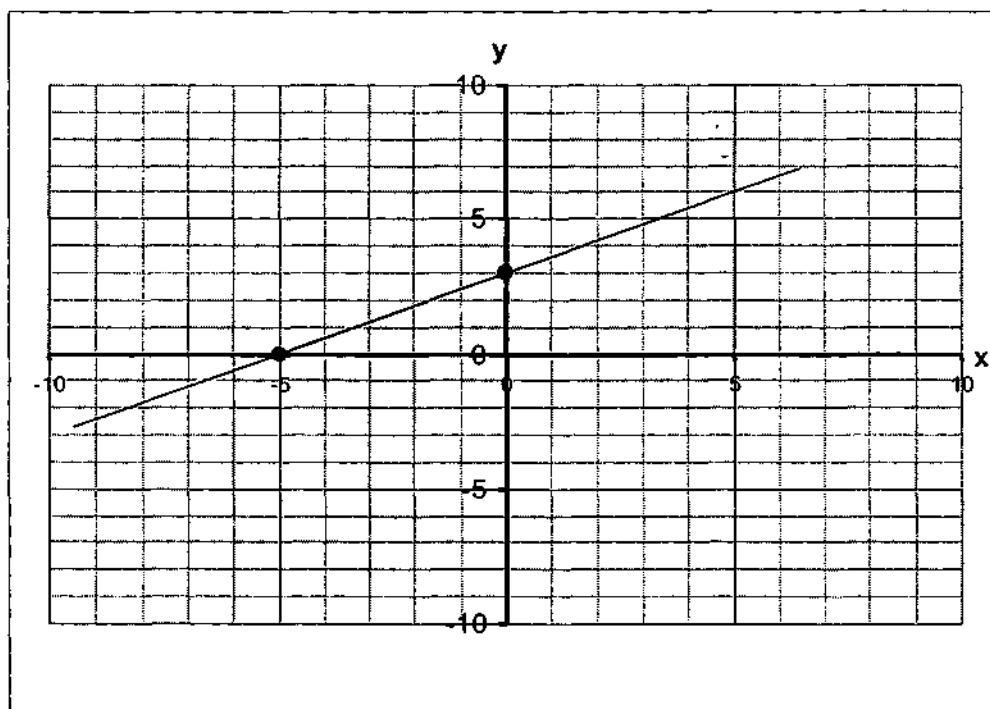
--

7.

- i) What is the gradient of the line which passes through the two points A(-2, -5) and B(5, 4) shown on the chart?

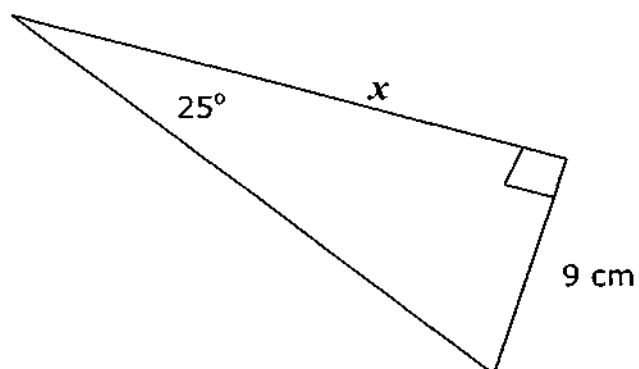


- ii) What is the equation of the line which passes through the two points A(0, 3) and B(-5, 0) shown on the chart?

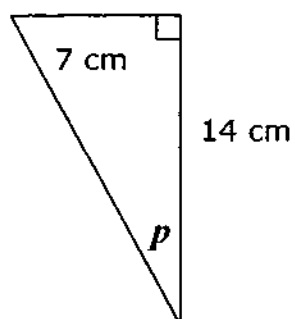


8. Find the unknown angle, p , or length, x , in each of the following diagrams.

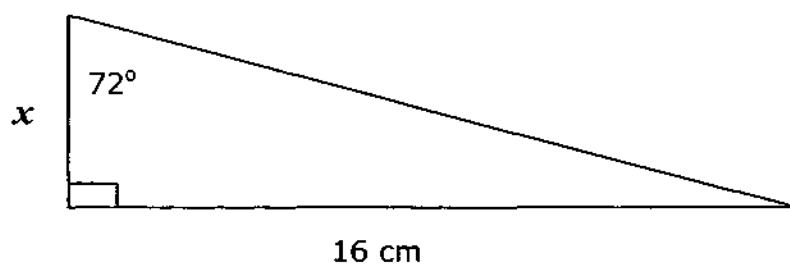
i)



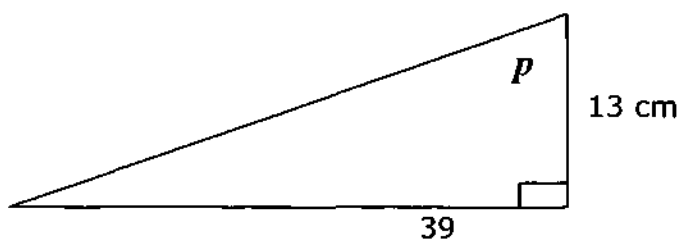
ii)



iii)



iv)



Appendix J: Test 1 - Fractions

1. Calculate and give answers as mixed numbers.

i) $\frac{3}{4} \times \frac{8}{9}$

ii) $\frac{3}{4} + \frac{8}{9}$

iii) $3\frac{2}{5} - 1\frac{1}{4}$

iv) $2\frac{1}{2} \times 3\frac{1}{4}$

v) $2\frac{1}{2} \div \frac{5}{8}$

vi) $2\frac{1}{2} \div (\frac{5}{8} + \frac{3}{4})$

vii) $12\frac{1}{2} \times (\frac{4}{7} + \frac{3}{4})$

viii) $2\frac{3}{10} \times (1\frac{5}{16} - \frac{3}{4})$

ix) $2\frac{3}{4} \times 3\frac{1}{2} - \frac{3}{4} \div \frac{1}{8}$

x) $4\frac{3}{4} - \frac{3}{4} \times \frac{1}{2} \div \frac{1}{8}$

2. The formula for displacement, s , is

$$s = \frac{(u + v)t}{2}$$

Find s when,

i)

$$u = -2$$

$$v = 8$$

$$t = 2$$

ii)

$$u = -3$$

$$v = -8$$

$$t = 5$$

3. The average lowest temperature on three successive nights is given by

$$T = \frac{T_1 + T_2 + T_3}{3} \text{ where } T_1, T_2 \text{ and } T_3 \text{ are the lowest temperatures on}$$

each night. Find T when,

i) $T_1 = -2; T_2 = 4; T_3 = -5$

ii) $T_1 = -8; T_2 = 2; T_3 = -2$

Appendix K: Test 2 - Solve equations

1. Solve the following equations.

i) $5x - 9 = 4$

ii) $30 = 4x - 6$

iii) $30 - 2x = 14$

iv) $2x + 4 = 3x - 3$

v) $5(x + 4) = 20$

vi) $\frac{5(x + 4)}{2} = 20$

2. The perimeter of a triangle is

$$P = a + b + c$$

i) Find c when $P = 25$; $a = 9$; $b = 10$.

ii) Find a when $P = 30$; $b = 15$; $c = 8$.

iii) Find c when $P = 15$; $a = 4$; $b = 5$.

3. The profits made by a company on the sales of a particular item are

given by the formula, $P = 75n - 4500$, where n is the number of items sold and P is in £.

i) If $n = 100$ then calculate P

ii) How many items must be sold to give a profit of £2,000?

iii) How many items must be sold to break even ($P = 0$)?

Appendix L: Test 3 - Transposition of formulae

1. Make a the subject of this equation

$$f = 2 + 3a$$

2. Make V the subject of this equation.

$$K = \frac{PV}{T}$$

3. Make R the subject of this equation.

$$B = I(1 + R)$$

4. Make C the subject of this equation.

$$F = 32 + \frac{9C}{5}$$

5. Make L the subject of this equation.

$$A = L^2$$

6. Make L the subject of this equation.

$$A = L^2 - 1$$

7. Make G the subject of this equation.

$$k = \frac{L + W}{G}$$

8. Make x the subject of this equation.

$$y = \frac{2}{x + 3}$$

9. Make w the subject of this equation.

$$D = T + \frac{1}{w}$$

10. Make p the subject of this equation.

$$\frac{1}{r} = \frac{1}{p} + \frac{1}{q}$$

Appendix M: Test 4 - Indices

1. Evaluate

i) 4^2

ii) $\left(\frac{1}{2}\right)^3$

2. Write these expressions as a single letter to a power.

i) $k \times k$

ii) $p \times p \times p \times p$

3. Write these expressions as a fraction with no indices.

i) 5^{-1}

ii) 10^{-2}

4. Write these expressions as a single letter to a power.

i) $\frac{1}{q \times q \times q}$

ii) $\frac{1}{h \times h \times h \times h \times h}$

5. Evaluate.

i) $16^{\frac{1}{4}}$

ii) $27^{\frac{2}{3}}$

6. Simplify.

i) $r^3 \times r^6$

ii) $s^{-1} \times s^4$

iii) $\frac{2^{12}}{2^{10}}$

iv) $\frac{t^4}{t^{\frac{1}{2}}}$

7. Evaluate or simplify.

i) $(2^2)^3$

ii) $(a^2)^3$

iii) $(d^{\frac{1}{2}})^3$

iv) $(\sqrt[4]{k})^{12}$

v) $\left(\frac{1}{g^4}\right)^3$

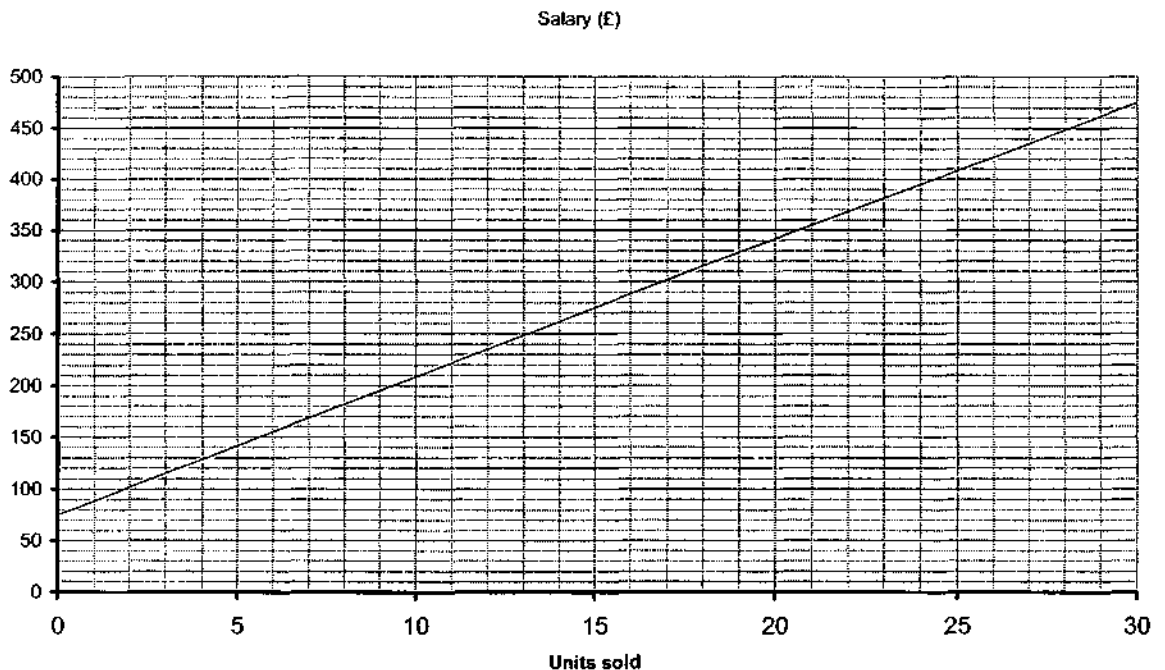
vi) $\sqrt[3]{c^6}$

Appendix N: Test 5 - graphs

Name: _____

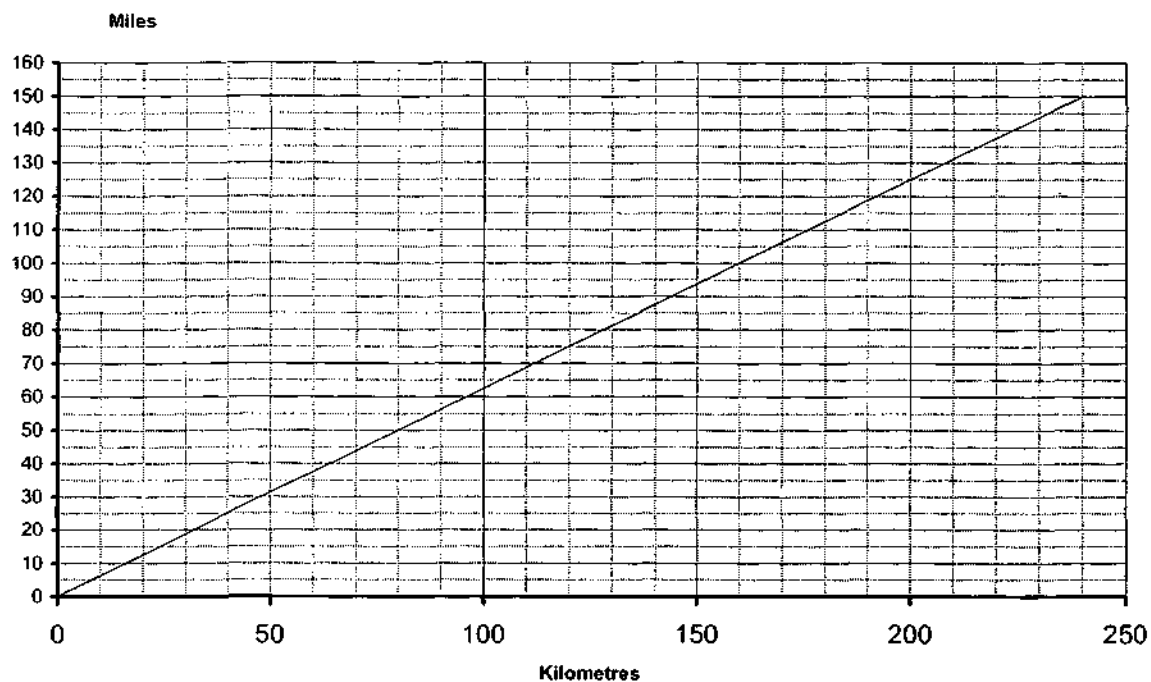
1. The graph shows relationship between the salary and the number of sales made by a salesperson.

i) If the person sells 17 units, how much salary is earned?	
ii) How many units would have to be sold to earn more than £350?	



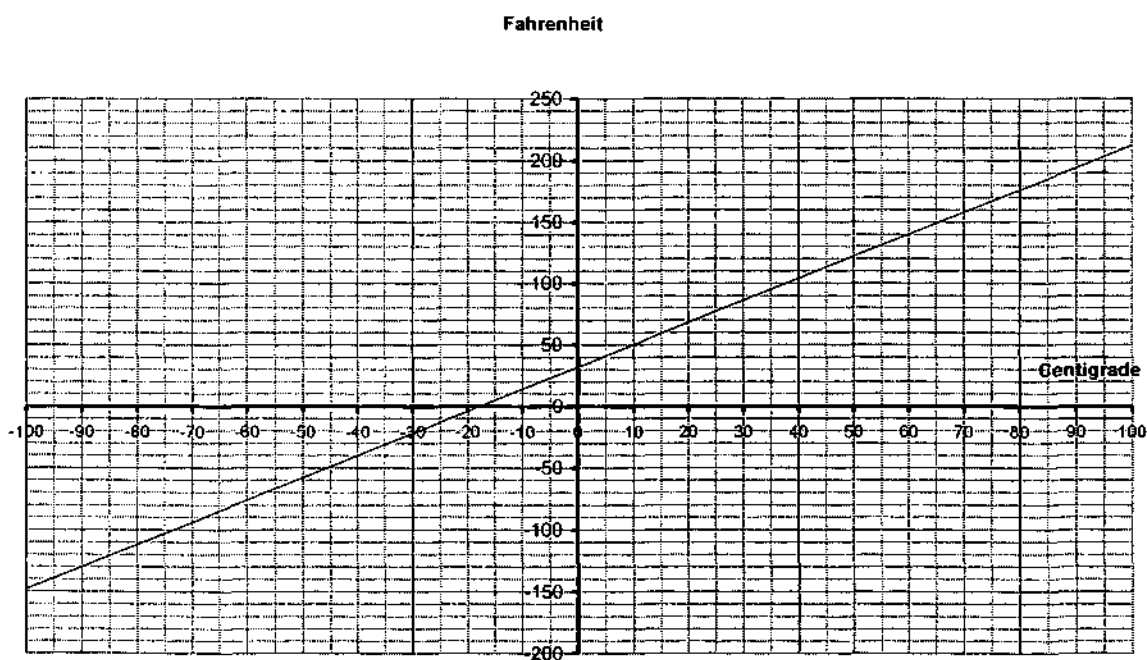
2. The graph shows relationship between miles and kilometres.

To the nearest 5 miles, how many miles is 110 km?	
To the nearest 5 km, how many kilometres is 90 miles?	



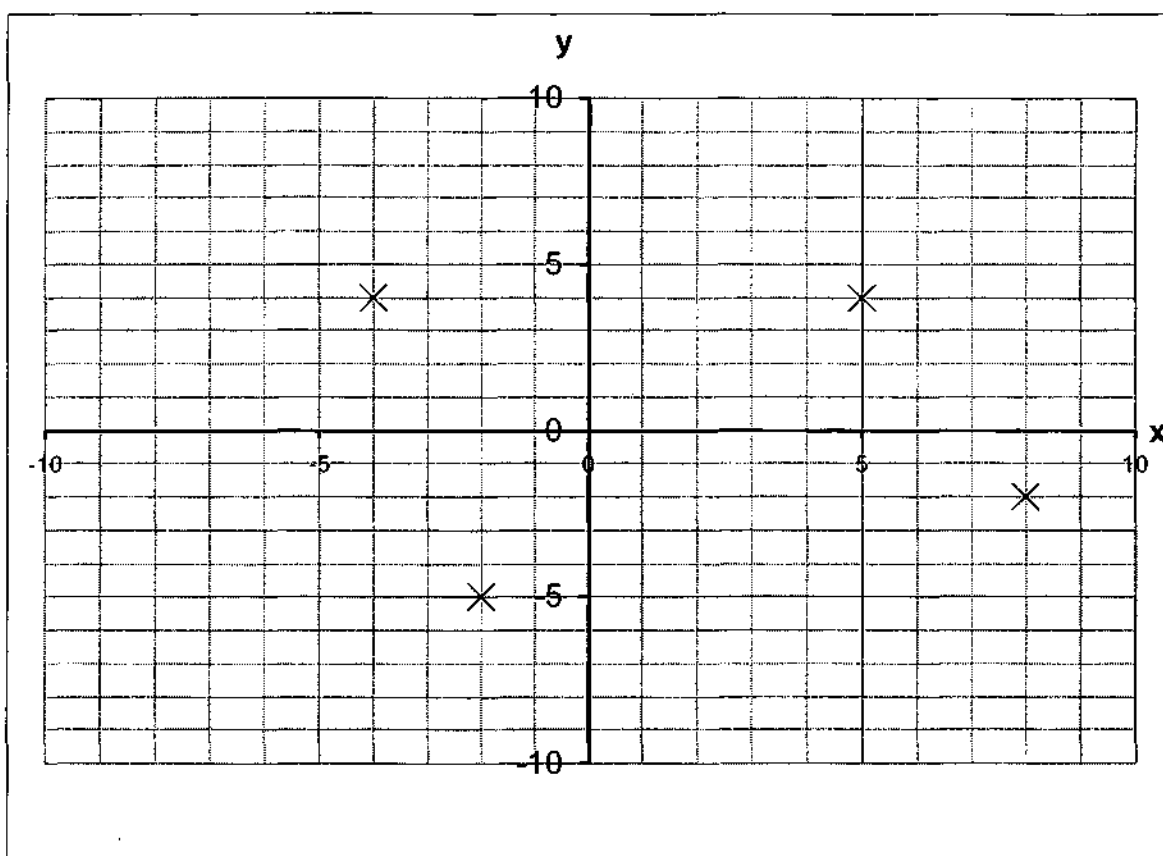
3. The graph (3) shows relationship between temperature in degrees Fahrenheit ($^{\circ}$ F) and degrees Centigrade ($^{\circ}$ C).

Use the graph to convert 60° F to $^{\circ}$ C.	
Use the graph to convert -40° C to $^{\circ}$ F.	



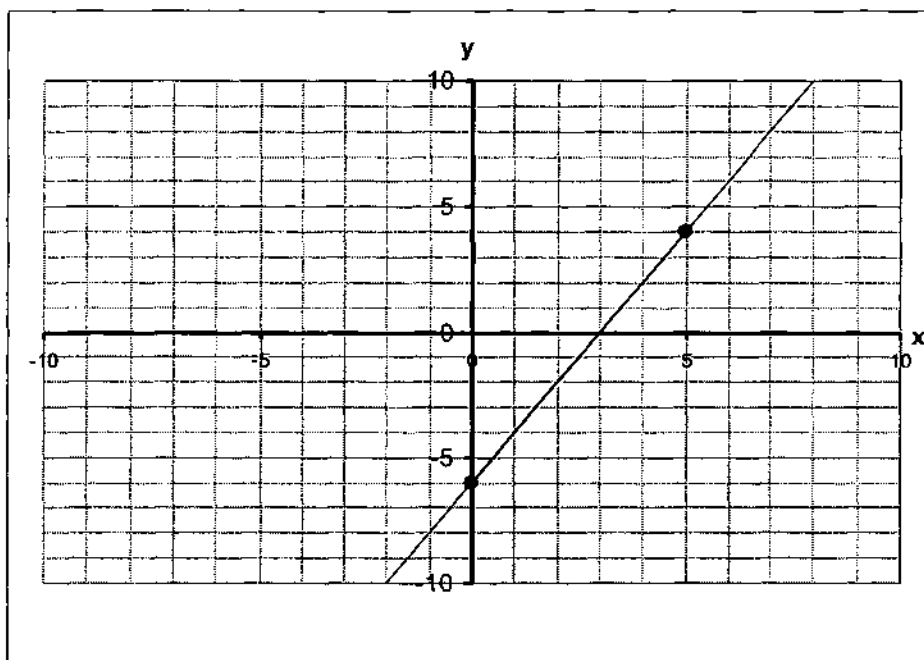
4. Complete the table to show the coordinates of the 4 points, A, B C, and D on the chart.

$P(x, y)$
A
B
C
D

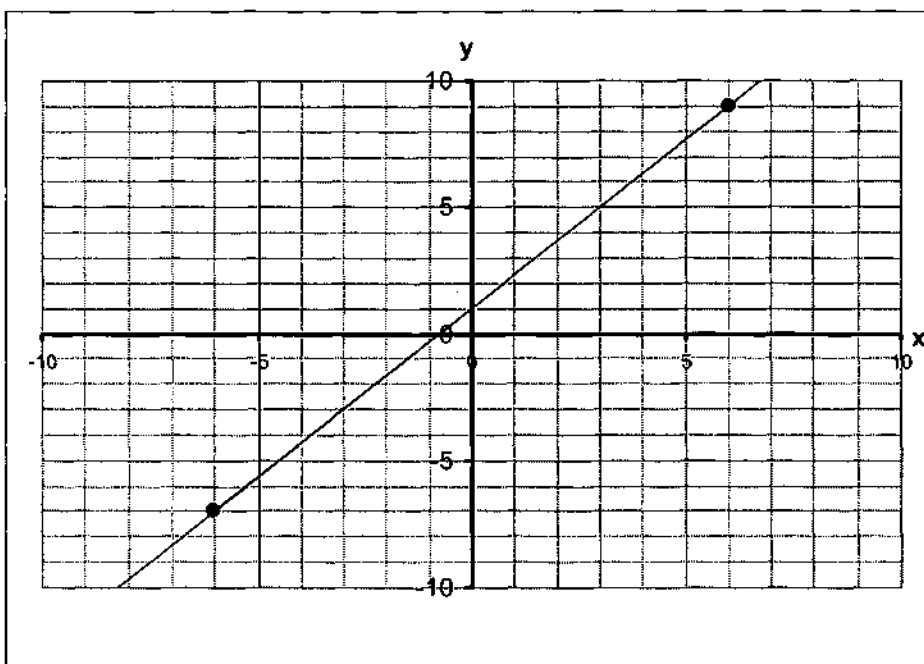


Appendix P: Test 6 - Equation of a straight line

1. What is the equation of the line which passes through the two points A (0, -6) and B (5, 4) shown on the chart?



2. What is the equation of the line which passes through the two points A (-6, -7) and B (6, 9) shown on the chart?

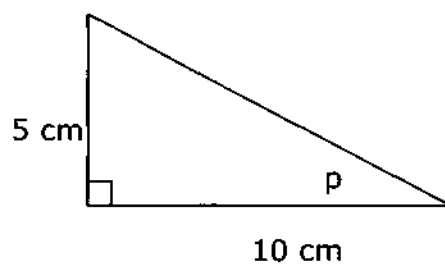


Appendix Q: Test 7 - Trigonometry

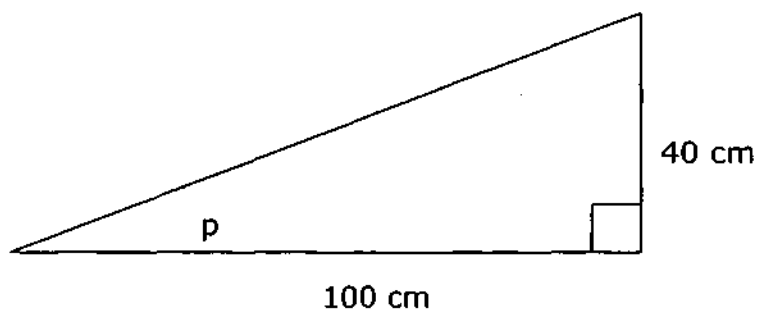
Name: _____

1. Find the angle marked 'p' in each of the triangles below.

i)

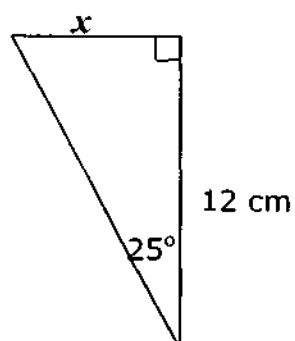


ii)

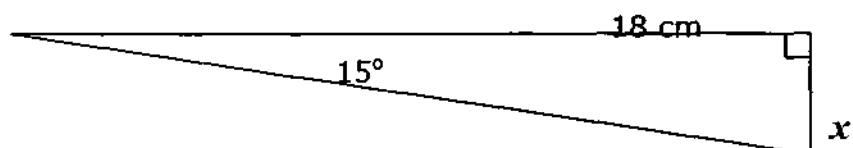


2. Find the length of the opposite side, marked x , in each of the following diagrams.

i)

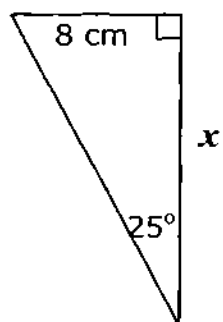


ii)

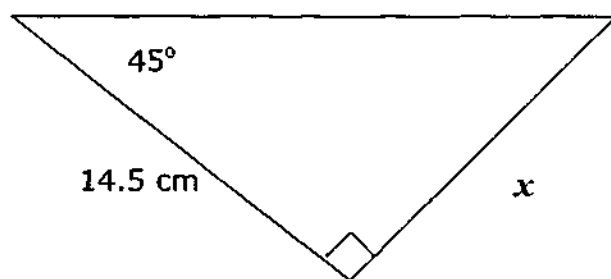


3. Find the length of the adjacent side, marked x , in each of the following diagrams.

i)

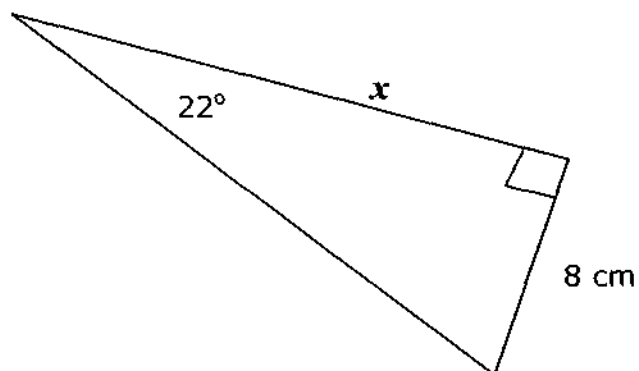


ii)

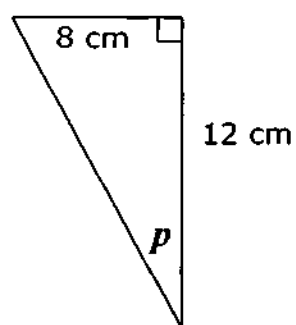


4. Find the unknown angle, p , or length, x , in each of the following diagrams.

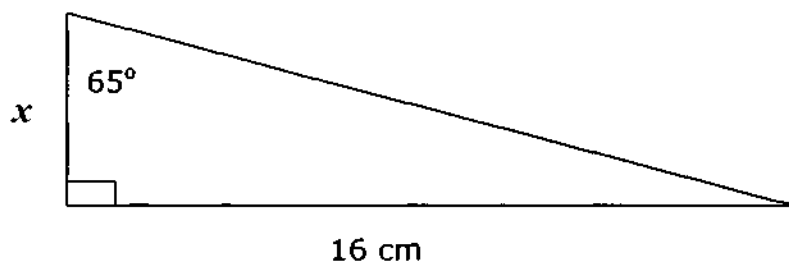
i)



ii)



iii)



iv)

